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Franklin Institute.

In accordance with Article XII, Section 1, of the By-Laws, no meeting of the Institute was held in July.

The following donations to the library were received, and reported at the meeting of the Board of Managers, held July 11th, 1877.

Forty-first annual report of the Executive Committee of the Young Men's Association. Buffalo, N. Y., 1877. From the Association.

Statistics of the American and Foreign iron trades. Annual Report of the Secretary of the A. I. & S. Association. Philad'a, 1877. From the Association.

Specifications and drawings of patents issued from the U. S. Patent Office for December, 1876, and January, 1877. Washington, 1877. From the Patent Office.

Narrative of the North Polar expedition, U. S. Ship *Polaris*, Chas. F. Hall, Commanding. By C. H. Davis, U. S. N. Washington, 1876. From the Navy Department.

Tenth report of the Provost to the Trustees of the Peabody Institute. June 1st, 1877. From the Institute.

Tableau statistique des chemins de fer de la Suède, de la Norwège et du Denmark for 1875.

Annual report of the Commissioner of Patents, with Index of Official Gazette and monthly vols. for 1876. Washington, 1877.
From the U. S. Patent Office.

United States trade-mark statutes, and rules of practice in trade-mark cases in the U. S. Patent office, January, 1877.

Rules of practice in the U. S. Patent Office, November, 1876.

Rules of practice in interferences in the U. S. Patent Office, November, 1876.

Patent Laws, August, 1876.

Decisions of the Commissioner of Patents and U. S. Courts, 1871-1876. From Patent Office.

Annual report of the Chief of the Bureau of Steam Engineering for the year 1876. Navy Dep't. Washington, 1876.

Report on safety-valve tests, made at the U. S. Navy Yard, Washington, D. C., Sept., 1875. Washington, 1877.
From the Bureau of Steam Engineering.

Forty-fourth annual report of the Royal Cornwall Polytechnic Society, 1876. From the Society.

Haus- und Landwirthschafts-Kalender des landwirthschaftlichen Vereins in Bayern. 1877.

Abhandlungen de K. K. Geologischen Reichsanstalt. Vol. 9. Wien, 1877. From the K. K. Geol. Reich.

Germanischer Lloyd. Deutsche Gesellschaft zur Classificirung von Schiffen. Internationales Register, 1877. From John Haug.

Useful Information for Engineers, Boiler Makers and Firemen, by W. B. LeVan. Philad'a, 1876. From the Author.

The Sciopticon Manual. By L. J. Marcy. Philadelphia, 1874. From the Author.

Practical Treatise on Lightning Protection. By H. W. Spang. Philad'a, 1877. From the Author.

Lessons in Electricity at the Royal Institution, 1875–6. By John Tyndall. New York, 1877. From C. W. Myers.

Report of the Chief Engineer, J. W. King, U. S. N., on European Ships of War. Washington, 1877. From the Author.

Geological survey of Canada. Report of progress for 1875–76. From the Director of the Survey.

Histoire des recherches sur la Quadrature du Cercle, par Montucla. From W. P. Tatham.

Continued from July number.

Eighteenth annual report of the trustees of the Cooper Union, for the advancement of Science and Arts. May 29th, 1877. N. Y. From the Union.

Bulletins of the United States Geological and Geographical Survey of the Territories. Vol. 3, Nos. 2 and 3. Wash., 1877.

List of elevations, principally in that portion of the United States west of the Mississippi River. 4th Ed. By H. Gannett. Wash., 1877.

Bulletin of the United States Entomological Commission, No. 2. Wash., 1877. From the Dept. of the Interior.

J. B. KNIGHT, *Secretary.*

Attraction and Repulsion.—Wüllner has experimented with Geissler tubes, supplied with air and other gaseous substances. In all cases the electric column undergoes an attraction under a pressure of 4 to 12 millimetres, and a repulsion under a pressure of 1 to 2 millimetres. Between these extremes there is a neutral point, at which neither attraction nor repulsion is observed. Some experiments with the electric egg confirm Prof. Peirce's theory with regard to the formation of comets' tails, while the change from attraction to repulsion, and *vice versa*, may find a satisfactory physical explanation in the theory of Prof. W. A. Norton.—*Les Mondes; Acad. Imp. de Vienne.* C.

Specific Electric Action on the Radiometer.—In his third paper on the movements of radiating and irradiated bodies, F. Zöllner shows that the galvanic current not only affects the mica discs of the radiometer through the heating of the conducting wires, but that it also exerts a specific influence upon the surrounding gaseous medium, which is directly opposed to the effect produced by the increase of temperature. If the experiments of Edlund (Pogg. Ann., cxlix, 99), Streintz (Ib. cl, 368), and Exner (Wiener Ber., May, 1873), are confirmed, the galvanic current possesses an analogous specific influence relative to the expansion of bodies; for according to those experiments, a galvanic conducting wire expands more than it ought in consequence of the heat that is developed in it.—*Pogg. Ann.*, clx, 463. C.

TRACTION OF LOCOMOTIVES.

In the construction of many of our railroads over the mountains, various expedients have been adopted to work the lines before final completion, which have given us much valuable information in regard to working heavy gradients. On the Baltimore and Ohio Railroad, before the completion of the Kingwood Tunnel, the cars ran over the mountain on a gradient of 1 in 10, or 528 feet per mile. The engines used to work these grades were known as camel-backs, and weighed, when in running order, 24 tons—all of the weight resting on 8 driving wheels $4\frac{1}{2}$ feet in diameter; size of cylinders 17×24 inches. The tender, with a full complement of fuel and water, weighed 13 tons. These engines would take up this steep gradient of 1 in 10 an eight-wheel flat car loaded with iron rails, total weight of car and load, 13 tons. The speed obtained was about 12 miles an hour.

The Mountain Top Incline on the Virginia Central Railroad, crosses the Blue Mountains at Rock Fish Gap in Virginia, at an elevation of 1885 feet above the sea. The maximum gradient is 1 in 17·86, and the minimum gradient, with a single exception, is 1 in 22·22. The engines, chiefly, to work these grades have 6 drivers $3\frac{1}{2}$ feet in diameter, length of wheel base 9 feet 4 inches, cylinders $16\frac{1}{2} \times 20$ inches, and weigh $24\frac{1}{2}$ tons. In working steep gradients, the adhesion has in many instances been found equal to $\frac{3}{5}$ of the weight upon the driving wheels.

Mr. Zerah Colburn, with an engine weighing 26·8 tons, 19·2 tons on 6 driving wheels, has drawn a train of 50 loaded eight-wheeled wagons, weighing upwards of 756 tons, up a continuous incline two miles in length of 1 in 132. So far as it has been possible to trace the construction of the locomotives having the greatest percentage of adhesion, the length of the stroke has been from 1·30 to 1·45 times the diameter. It is believed that the adhesion of the driving wheels is largely influenced by the manner of admitting steam to the cylinders, as well as the speed and weight of the engine.

From a large number of experiments made with the dynograph, by Mr. P. H. Dudley, on different roads, with engines of short stroke, the adhesion is found not to exceed one-third of the weight on the drivers, and in many cases but little over one-fourth.

As opportunity shall offer, Mr. Dudley will continue these experiments, to determine what may prove to be a very important factor in the economical working of locomotives. K.

Warming and Ventilation.—Flavitsky uses double windows, placing an air-chamber under each window, into which the fresh outside air is admitted, and heated by ribbed tubes, by means of water or steam. The hot air rises between the windows, and enters the room near the ceiling.—*Ann. du genie civil*, July, 1876; *Zeits. des Arch. u. Ing.-Ver. zu Hannover*, xxiii, 298. C.

Economy in Steam Engines.—M. O. Hallauer has published a report of experiments upon steam engines, with saturated and with superheated steam, under various conditions. One of the most important results seems to be the demonstration of the importance of the exchanges of heat between the steam and the walls of its receptacles. By making proper allowance for such exchanges, a remarkable accordance is found between theoretical and practical values. Superheated steam gave a saving of 23 per cent., over saturated steam. The condenser realized an economy of 43 per cent.—*Bull. de la Soc. Ind. de Mulhouse, l. c.* C.

Improved Mortar and Artificial Stones.—M. Decourneau attributes the cracks in common mortars and cements, to the uncombined quicklime that they contain. In order to neutralize the lime, he uses an *agrégat*, composed of a very fine siliceous powder mixed with diluted nitric acid. He thus obtains mortars with much greater, more uniform and more lasting resistance than those hitherto used. The application of his method, especially in the new forts of Paris, has given excellent results, without a single failure. Stone made by his process, may be sawed and chiseled like natural stone.—*Soc. d'Enc. pour l'Ind. nat.; Les Mondes*, May 24. C.

Packing Paper.—Packing paper may be made water-tight by dissolving 1·82 pounds of white soap in one quart of water, and dissolving in another quart 1·82 ounces (Apothecaries' weight) of gum arabic, and 5·5 ounces of glue. The two solutions are to be mixed and warmed, the paper soaked in the mixture, and passed between rollers or hung up to dry.—*Fortsch. der Zeit.*, May 15. C.

Vegetable Leather.—M. A. Müntz has found that nitrogenous vegetable tissues are able, like the skins of animals, to absorb and fix tannin, and thus acquire a greater consistency, which forms a sort of vegetable leather. The amount of fixed tannin depends upon the amount of nitrogen in the vegetable. Some mushroom tissues fixed from 60 to 86 per cent. of their weight; beans, 17·2 per cent. —*C. R.*, April 30. C.

Book Notices.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY. No. 99, January to May, 1877.

Contains papers on the progress of the "North American Carboniferous Flora," now in preparation, L. Lesquereux; Tabular Synopsis of the Rhynchophora of America, J. L. Le Conte; Refraction Tables, A. K. Mansfield; E. S. Nettleton's first systematic collection of Oil Well Records in Venango County, J. F. Carll; Centres of Aggregation and Dissociation, P. E. Chase; Astrophyllite, Arfvedsonite and Zircon from El Paso, G. A. König; Measured Section of the Patleozoic Rocks of Central Pennsylvania, C. A. Ashburner; Coahuila, T. L. Kane; Continuation of Researches among the Batrachia of the Coal Measures of Ohio, a Dinosaurian from the Trias of Utah, and the Brain of Coryphodon, E. D. Cope; Composition of the Natural Gas from certain Oil Wells, S. P. Sadtler; Eight Meteoric Fireballs seen in the United States in 1876–7, and the Relative Ages of the Sun and certain of the Fixed Stars, D. Kirkwood; the Asserted Antagonisms between Nicotine and Strychnia, F. L. Haynes; a New Eurypteroid from the Coal Measures of Pennsylvania, C. E. Hall; the Timucua Language, A. S. Gatschet; Approaches to a Theory of the Cause of Magnetic Declination, and regarding some Mesozoic Ores, P. Frazer, Jr.; Experimental Tests of American Condensed Peat, J. B. Britton; Syllabus of Lectures on Sylviculture, J. T. Rothrock. C.

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES. Part I, for 1877.

Contains papers on Astrophyllite, Arfvedsonite and Zircon, G. A. König; Fertilization of Browallia elata, Asa Gray; Ibid., Thos. Meehan; Hudson River and Utica Slates of Pennsylvania, Anthracite from "Third-Hill Mountain," W. Va., Copper-bearing rocks of the Mesozoic Formation, and Contamination of Drinking Water, P. Frazer, Jr.; Contamination of Drinking Water, Eozoon, and The Diaphragm, J. Leidy, M. D.; Generic names proposed by Zittel, Stoliczke, and Zekeli, and Notes on Shells, T. A. Conrad; Unionidae of Ohio and Alabama, J. Lewis, M. D.; The Giraffe, H. C. Chapman, M. D.; The Habits of Quiscalus purpureus, J. Willcox; Excrementitious deposits found in the West, H. W. Henshaw; Fishes of Northern Ind., D. S. Jordan, M. D.; Genera of North American Fresh-water Fishes, Id. and C. H. Gilbert; List of Plants recently collected on Ships' Ballast in the neighborhood of Philadelphia, I. Burk; The Valsei of the United States, M. C. Cooke; Influence of Nutrition on Fertilization, The Blue-bird and Holly Berries, Vitality of Seeds under low temperature, and Evolutionary Law as illustrated by Ab-

normal Growth in an Apple Tree, T. Meehan; Rocky Mountain Locusts, J. L. Le Comte, M. D.; Mineral Caoutchouc, G. C. Morris; Vital Power of Ants, Rev. H. C. McCook. C.

A Practical Treatise on Lightning Protection.—By Henry W. Spang. 12mo, pp. 180, with illustrations, cloth, $1.50. Claxton, Remsen & Haffelfinger. Philadelphia, 1877.

The author begins the work with an effort to instruct the reader upon the subject of electricity in its various phases, but more especially in its static condition, and as displayed in the phenomenon of thunderstorms. This occupies 68 pages, and while reasonably correct in its bearing on lightning protection, it contains some strange statements. For instance, on page 47, in speaking of electrical accumulations in the air and earth, he says: "In the earth it (the "electricity) is principally spread out over the subterranean water "bed" . . . While all will agree that moist earth is a much better conductor than dry, we know of no evidence that the electricity in the earth is localized.

Then follows a description of the various means employed for protection from lightning, including conductors, air and earth terminals, attachments to buildings, etc., in which the best methods are very clearly pointed out.

While several varieties of conductors, and methods of making good connections and attachments to buildings are approved, all of them are based upon the requirement that the conductors shall be of ample cross-section of metal, and that they shall terminate in a large metallic surface, planted in constantly moist ground.

Only on the subject of earth terminals does there seem to be any bias of judgment.

All the earth terminals *now* offered for sale by "Lightning Rod Men," are, without exception, condemned, but one devised by the author is pronounced pre-eminently effective, although having no more surface exposed, nor sunk deeper in the soil, than some others mentioned. This, together with the last seven pages, headed "Reform in the Lightning Protection Business," are certainly blemishes in an otherwise really useful book. K.

Report on European Ships of War, their Armament, Naval Administration and Economy, Marine Construction and Appliances, Dock Yards, etc., etc.—By John W. King, U. S. N., Washington, 1877. Gov't Printing Office.

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Mr. King sailed from New York in August, 1875, under orders from the Secretary of the Navy, "for the purpose of personally ob-"serving and reporting upon recent construction and mechanical "appliances for ships of war." This report is the result of about

one year's study of this subject, and makes an 8vo volume of 273 pages and 29 illustrations, of armored ships, engines, guns, dock yards, etc.

Owing to the rapid strides made by the British Government in the last four years, in improving its own navy, and to the large number of war ships produced in England for other nations, that country proved to be the most fruitful field, and consequently we find 130 pages of the book devoted to the British War Vessels, while all other European navies are fairly noticed.

Mr. King finds that recently constructed war vessels of all classes are engined on the compound system, and reiterates the remarks made in his report as Chief of the Bureau of Steam Engineering, dated October 30th, 1871, that "there can be no hesitation in rec-"ommending that all cruising steamers of the navy, hereafter put "afloat, be engined on the compound system, and that all steam ma-"chinery, stored in the navy yards, that cannot be used to advantage "in old vessels, or converted into compound, be disposed of by public "sale, or broken up and used as old material."

Among other conclusions arrived at, Mr. King believes that, considering the fact that in the European navies the power of the guns and the weight and thickness of armor have continued to increase, it will result greatly to our advantage that we did not, after the civil war, go on building armored ships; that, had we done so, we should now have an antiquated armored fleet, while on the other hand "we "are now at liberty to take advantage of the results of the most "expensive and exhaustive experiments made by foreign powers, in "the construction of ships, of machinery of various kinds for naval "purposes, and in the manufacture of weapons."

Mr. King has drawn largely from the current engineering literature, government documents, etc., so that portions of the report are by no means new, but he has added much that is due to his personal investigation, and has arranged an amount of information in a systematic, compact form, such as has not hitherto been readily available. K.

USEFUL INFORMATION FOR ENGINEERS, BOILER MAKERS AND FIREMEN. By W. Barnett LeVan.

This little manual, compiled largely from works of standard authors, will be found very useful to owners and managers of steam boilers. Considerable space is given to the discussion of the proper strength and thickness of plates and tubes, and to the effects of the various operations upon these materials in the course of construction. It also contains rules and tables for determining the proper grate area, and area and length of chimney flues. To this is added much practical information derived from the author's own experience, which, together with the excellent statement as to the causes and prevention of explosions, will greatly aid in the economical and safe working of steam boilers. K.

DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, AND A NEW THEORY OF THE SOLAR SPECTRUM.

By Prof. HENRY DRAPER, M. D.[1]

[Read before the American Philosophical Society, July 20th, 1877.]

I propose in this preliminary paper to indicate the means by which I have discovered Oxygen, and probably Nitrogen, in the Sun, and also to present a new view of the constitution of the Solar Spectrum.

Oxygen discloses itself by bright lines or bands in the Solar Spectrum, and does not give dark absorption lines like the metals. We must therefore change our theory of the Solar Spectrum, and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, etc., but also may account for some of the so-called dark-lines, by regarding them as intervals between bright lines.

It must be distinctly understood that in speaking of the Solar Spectrum here, I do not mean the spectrum of any limited area upon the disc or margin of the Sun, but the spectrum of light upon the whole disc. I have not used an image of the Sun upon the slit of the spectroscope, but have employed the beam reflected from the flat mirror of the heliostat without any condenser.

In support of the above assertions the accompanying photograph of the Solar Spectrum with a comparison spectrum of air, and also with some of the lines of iron and aluminium, is introduced. The photograph itself is absolutely free from handwork or retouching. It is difficult to bring out in a single photograph the best points of these various substances, and I have therefore selected from the col-

[1] This paper has been pronounced, by able judges, to be the most important contribution to solar physics since Kirchhoff's great discovery. It is just thirty-five years since the author's father, Dr. John W. Draper, read his first paper on Activision, before the American Philosophical Society.

lection of original negatives that one which shows the Oxygen coincidences most plainly. There are so many variables among the conditions which conspire for the production of a spectrum, that many photographs must be taken to exhaust the best combinations. The pressure of the gas, the strength of the original current, the number of Leyden jars, the separation and nature of the terminals, the number of sparks per minute, and the duration of the interruption in each spark, are examples of these variables.

In the photograph the upper spectrum is that of the Sun, and above it are the wave-lengths of some of the lines to serve as reference numbers. The wave-lengths used in this paper have been taken partly from Angström and partly from my photograph of the diffraction spectrum published in 1872. The lower spectrum is that of the open air Leyden spark, the terminals being one of Iron and the other of Aluminium. I have photographed Oxygen, Nitrogen, Hydrogen and Carbonic Acid, as well as other gases, in Plücker's tubes, and also in an apparatus in which the pressure could be varied, but for the present illustration, the open air spark was, all things considered, best. By other arrangements the Nitrogen lines can readily be made as sharp as the Oxygen are here, and the Iron lines may be increased in number and distinctness. For the metals the electric arc gives the best photographic results, as Lockyer has so well shown, but as my object was only to prove by the Iron lines that the spectra had not shifted laterally past one another, those that are here shown at 4325. 4307. 4271. 4063. 4045. suffice. In the original collodion negative many more can be seen. Below the lower spectrum are the symbols for Oxygen, Nitrogen, Iron and Aluminium.

No close observation is needed to demonstrate to even the most casual observer that the Oxygen lines are found in the sun as bright lines, while the Iron lines have dark representatives. The bright Iron line at G (4307), on account of the intentional overlapping of the two spectra, can be seen passing up into the dark absorption line in the Sun. At the same time the quadruple Oxygen line between 4345 and 4350 coincides exactly with the bright group in the Solar Spectrum above. This Oxygen group alone is almost sufficient to prove the presence of Oxygen in the Sun, for not only does each of the four components have a representative in the Solar Spectrum, but the relative strength and the general aspect of the lines in each

case are similar. I do not think that in comparisons of the spectra of the elements and Sun, enough stress has been laid on the general appearance of lines apart from their mere position; in photographic representations this point is very prominent. The fine double line at 4319. 4317. is plainly represented in the Sun. Again there is a remarkable coincidence in the double line at 4190. 4184. The line at 4133 is very distinctly marked. The strongest Oxygen line is the triple one at 4076. 4072. 4069., and here again a fine coincidence is seen, though the air spectrum seems proportionately stronger than the solar. But it must be remembered that the Solar Spectrum has suffered from the transmission through our atmosphere, and this effect is plainest in the absorption at the ultra-violet and violet regions of the spectrum. From some experiments I made in the summer of 1873, it appeared that this local absorption is so great, when a maximum thickness of air intervenes, that the exposure necessary to obtain the ultra-violet spectrum at sunset was two hundred times as long as at midday. I was at that time seeking for atmospheric lines above H like those at the red end of the spectrum, but it turned out that the absorptive action at the more refrangible end is a progressive enfeebling as if a wedge of neutral tinted glass were being drawn lengthwise along the spectrum towards the less refrangible end.

I shall not attempt at this time to give a complete list of the Oxygen lines with their wave lengths accurately determined, and it will be noticed that some lines in the air spectrum which have bright analogues in the sun are not marked with the symbol of Oxygen. This is because there has not yet been an opportunity to make the necessary detailed comparisons. In order to be certain that a line belongs to Oxygen, I have compared, under various pressures, the spectra of Air, Oxygen, Nitrogen, Carbonic Acid, Carbureted Hydrogen, Hydrogen and Cyanogen. Where these gases were in Plücker's tubes a double series of photographs has been needed, one set taken with, and the other without, Leyden jars.

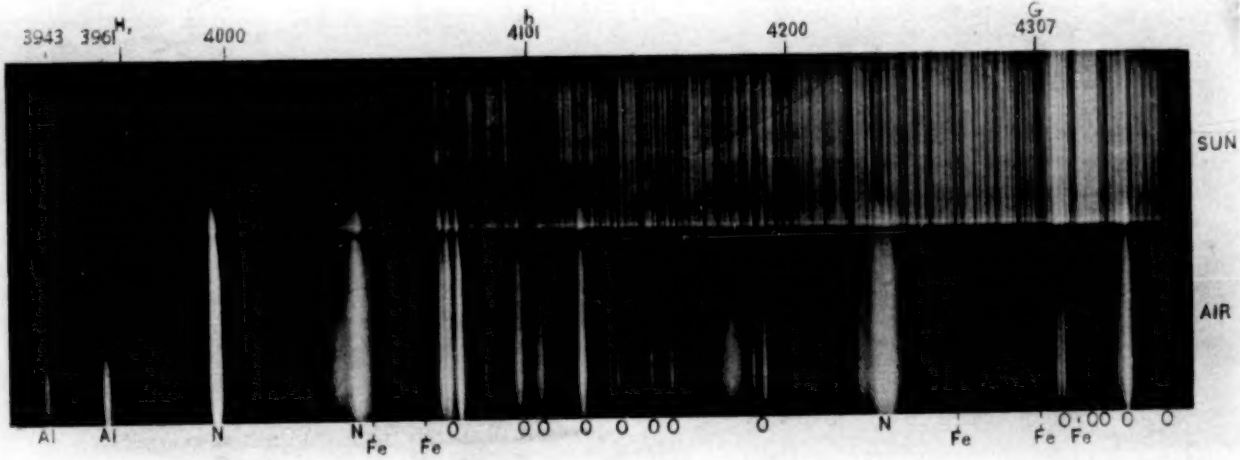
As to the spectrum of Nitrogen and the existence of this element in the sun, there is not yet certainty. Nevertheless, even by comparing the diffused Nitrogen lines of this particular photograph, in which Nitrogen has been sacrificed to get the best effect for Oygen, the character of the evidence appears. The triple band between 4240. 4227. if traced upward into the Sun has approximate repre-

sentatives. Again at 4041. the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3995., which in this picture is opposite an insufficiently exposed part of the Solar Spectrum, shows a comparison band in the Sun.

The reason I did not use air in an exhausted Plücker's tube for the production of a photograph to illustrate this paper, and thus get both Oxygen and Nitrogen lines well defined at the same time, was partly because a brighter light can be obtained with the open air spark on account of the stronger current that can be used. This permits the slit to be more closed and of course gives a sharper picture. Besides the open air spark enabled me to employ an iron terminal, and thus avoid any error arising from accidental displacement of the reference spectrum. In Plücker's tubes with a Leyden spark the Nitrogen lines are as plain as those of Oxygen here. As far as I have seen, Oxygen does not exhibit the change in the character of its lines that is so remarkable in Hydrogen under the influence of pressure as shown by Frankland and Lockyer.

The bright lines of Oxygen in the spectrum of the solar disc have not been hitherto perceived, probably from the fact that in eye observation bright lines on a less bright background do not make the impression on the mind that dark lines do. When attention is called to their presence they are readily enough seen, even without the aid of a reference spectrum. The photograph, however, brings them into a greater prominence. From purely theoretical considerations derived from terrestrial chemistry and the nebular hypothesis, the presence of Oxygen in the sun might have been strongly suspected, for this element is currently stated to form eight-ninths of the water of the globe, one-third of the crust of the earth, and one-fifth of the air, and should therefore probably be a large constituent of every member of the solar system. On the other hand the discovery of Oxygen and probably other non-metals in the Sun gives increased strength to the nebular hypothesis, because to many persons the absence of this important group has presented a considerable difficulty.

At first sight it seems rather difficult to believe that an ignited gas in the solar envelope should not be indicated by dark lines in the solar spectrum, and should appear not to act under the law "a gas when ignited absorbs rays of the same refrangibility as those it emits." But in fact the substances hitherto investigated in the sun are really metallic vapors, Hydrogen probably coming under that rule.



DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, BY PROFESSOR HENRY DRAPER. M. D, 1876.

The upper part of the photograph is the spectrum of the Sun, the lower part is the spectrum of the Oxygen and Nitrogen of Air. The letters and figures on the margin are printed with type on the negative; with this exception the photograph is absolutely free from hand work or retouching. O. indicates Oxygen, N. Nitrogen, Fe. Iron, Al. Aluminium. The figures above the Sun's spectrum are wave-lengths; G. h, H., are prominent Solar lines at the violet end of the spectrum. The principal point to examine is the coincidence of the bright Oxygen lines with bright lines in the Solar spectrum. The picture is printed from Draper's original negative by Bierstadt's Albertype process.

The non-metals obviously may behave differently. It is easy to speculate on the causes of such behavior, and it may be suggested that the reason of the non-appearance of a dark line may be that the intensity of the light from a great thickness of ignited Oxygen overpowers the effect of the photosphere, just as if a person were to look at a candle flame through a yard thickness of ignited sodium vapor he would only see bright sodium lines, and no dark absorption lines. Of course, such an explanation would necessitate the hypothesis that ignited gases such as Oxygen give forth a relatively large proportion of the solar light. In the outburst of *T. Coronæ*, Huggins showed that Hydrogen could give bright lines on a background of spectrum analogous to that of the Sun.

However all that may be, I have no doubt of the existence of substances other than Oxygen in the Sun which are only indicated by bright lines. Attention may be called to the bright bands near G, from wave lengths 4307 to 4337, which are only partly accounted for by Oxygen. Farther investigation in the direction I have thus far pursued will lead to the discovery of other elements in the Sun, but it is not proper to conceal the principle on which such researches are to be conducted for the sake of personal advantage. It is also probable that this research may furnish the key to the enigma of the D_3 or Helium line, and the 1474 K or Corona line. The case of the D_3 line strengthens the argument in favor of the apparent exemption of certain substances from the common law of the relation of emission and absorption, for while there can be no doubt of the existence of an ignited gas in the chromosphere giving this line, there is no corresponding dark line in the spectrum of the solar disc.

In thus extending the number of elements found in the Sun, we also increase the field of inquiry as to the phenomena of dissociation and recomposition. Oxygen, especially from its relation to the metals, may readily form compounds in the upper regions of the solar atmosphere which can give banded or channeled spectra. This subject requires careful investigation. This diffused and reflected light of the outer corona could be caused by such bodies cooled below the self-luminous point.

This research has proved to be more tedious and difficult than would be supposed, because so many conditions must conspire to produce a good photograph. There must be a uniform prime moving engine of two horse-power, a dynamo-electric machine thoroughly adjusted, a

large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden jars carefully proportioned to the Plücker's tube in use, a heliostat, which of course involves clear sunshine, an optical train of slit, prisms, lenses and camera, well focussed, and, in addition to all this, a photographic laboratory in such complete condition that wet sensitive plates can be prepared which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over, the tube was ruined by the strong Leyden sparks. Moreover, to procure tubes of known contents is troublesome. For example, my hydrogen tubes gave a spectrum photograph of fifteen lines, of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen lines, it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the Sun.

The object in view in 1873, at the commencement of this research, was to secure the means of interpreting the photographs of the spectra of stars and other heavenly bodies, obtained with my 28-inch reflector. It soon appeared that the spectra of Nitrogen and other gases in Plücker's tubes could be photographed, and at first some pictures of Hydrogen, Carbonic Acid and Nitrogen were made, because these gases seemed to be of greatest astronomical importance on account of their relation to stars, nebulæ and comets. Before the subject of comparison spectra of the Sun was carefully examined, there was some confusion in the results, but by using Hydrogen the source of these errors was found out.

But in attempting to make a prolonged research in this direction, it soon appeared that it was essential to be able to control the electrical current with precision, both as to quantity and intensity, and, moreover, to have currents which when once adjusted would remain constant for hours together. These conditions are almost impossible to attain with any form of battery, but on the contrary are readily satisfied by dynamo-electric machines. Accordingly, I sought for a suitable dynamo-electric machine and motor to drive it, and after many delays procured a combination which is entirely satisfactory. I must here acknowledge my obligations for the successful issue of this search to Professor George F. Barker, who was the first person

in America to procure a Gramme machine. He was also the first to use a Brayton engine to drive a Gramme.

The dynamo-electric machine selected is one of Gramme's patent, made in Paris, and is a double light machine, that is it has two sets of brushes, and is wound with wire of such a size as to give a current of sufficient intensity for my purposes. It is nominally a 350 candle light machine, but the current varies in proportion to the rate of rotation, and I have also modified it by changing the interior connections. The machine can produce as a maximum a light equal to 500 standard candles, or by slowing the rotation of the bobbin the current may be made as feeble as that of the weakest battery. In practical use it is sometimes doing the work of more than 50 large Grove nitric acid cells, and sometimes the work of a single Smee.

The Gramme machine could not be used to work an induction coil when it first reached me, because when the whole current was sent through the Foucault interruptor of the Ruhmkorff coil, making 1000 breaks per minute, the electro-magnets of the Gramme did not become sufficiently magnetized to give an appreciable current. But by dividing the current so that one pair of the metallic brushes, which collect from the revolving bobbin, supplied the electro-magnets, the other pair could be used for exterior work, no matter whether interrupted or constant. The current obtained in this way from one pair of brushes when the Gramme bobbin is making 1200 revolutions per minute, is equal to 100 candles, and is greater in quantity than one would like to send through a valuable induction coil. I usually run the bobbin at 622 revolutions per minute, and this rate will readily give 1000 ten-inch sparks per minute, with the 18-inch coil. Of course a Plücker's tube lights up very vividly, and generally, in order to get the maximum effect, I arrange the current so that the aluminium terminals are on the point of melting. The glass, particularly in the capillary part, often gets so hot as to char paper.

As long as the Gramme bobbin is driven at a steady rate, the current seems to be perfectly constant, but variations of speed make marked differences in the current, and this is especially to be avoided when one is so near the limit of endurance of Plücker's tubes. A reliable and constant motor is therefore of prime importance for these purposes. A difference of 1 per cent. in the speed of the engine sometimes cannot be tolerated, and yet at another time, one must have the

power of increasing and diminishing the rate through wide limits. The only motor, among many I have examined and tried, that is perfectly satisfactory, is Brayton's Petroleum Ready Motor.

This remarkable and admirable engine acts like an instrument of precision. It can be started with a match, and comes to its regular speed in less than a minute; it preserves its rate entirely unchanged for hours together. Moreover, it is economical, cleanly, and not more noisy than a steam engine. The one of two-horse power I have, ran for six months, day and night, supplying water and air to the aquaria in the Centennial Exhibition at Philadelphia. At any time, on going into the laboratory, it can be started in a few seconds, even though it has not been running for days.

The Otheoscope.—In Crookes' radiometer, the warmed parts move, while the cooler parts commonly remain at rest. It seemed to the inventor of that ingenious instrument, that the best arrangement would be one in which the heated parts would be immovable, for it could be made of material best suited for the purpose, having sufficient extent of surface and the most favorable form, without regard to weight. The movable cold portion could be placed as near as possible to the warm, and it could be of such form, size and weight as would best utilize the effects produced. If the heated surfaces were of large dimensions, and made of silver, gold, copper, or other good heat-conductor, a very slight excitement of radiation would set up motion, and the blackened surfaces would act as if a molecular wind were escaping, normally to their plane. This wind easily puts in motion all the movable bodies that it meets, whatever may be their nature, color or form, acting at nearly every point like an ordinary wind. Such an instrument is called an otheoscope, from the Greek word *otheo*, to repel. Crookes exhibited several forms before the Royal Society at its meeting of April 25th, some of which worked in the open air, under the simple influence of solar light, without any receptacle for rarefied air. This new invention seems likely to enlarge, even more than the radiometer, our knowledge of the laws of molecular movements, movements which may be regarded as the key of the relations which exist between force and matter.—*C. R.*, May 14. C.

NOTES ON COMPENSATING-POWDER.

By Lieut. Chas. A. L. Totten, U. S. A.

[Continued from Vol. civ, page 63.]

Every theoretical consideration seems to support the argument in favor of the idea; is, then, its realization practicable? Unhesitatingly we answer in the affirmative. The consideration of this question opens several lines of investigation: the mechanical difficulties of manufacture, the chemical difficulties of combination, and finally the actual testing of the powder. To a certain extent, each of these points has already received the attention of the writer. In the present limited paper, however, it is only possible to glance at some of the more striking experiments that were instituted, and briefly study their inferences.

During the past year, at the Massachusetts Agricultural College, and with the assistance of Professor Gœssmann, the State Chemist, an exhaustive series of experiments was undertaken, with a view to determine the difference of the chemical action, if any, between the best American gunpowder, and English gun-cotton, when under various conditions and circumstances of mechanical combination. On the 1st of October, 1876, a number of jars were filled as follows: No. 1 contained Hazzard's best sporting powder, dry, and sealed. No. 2 contained the same as No. 1, but was left open to the air. No. 3 contained the same, but the contents were saturated with pure water. Nos. 4 and 5 were filled with gun-cotton, the one pulverized, the other in the disk form, and both dry. Nos. 6, 7 and 8 likewise contained gun-cotton, pure and in various forms, but saturated with pure water. The contents of all these jars were then carefully tested, and found to be absolutely devoid of free acid, or any other appreciable impurities. Jar No. 9 contained a quantity of dry cotton and powder thoroughly mixed. No. 10 was filled as No. 9, but the contents saturated with pure water. Nos. 11 and 12 contained dry powder and wet cotton. No. 13 contained dry cotton and wet powder. The contents of these jars were also carefully tested and found neutral to litmus, and true to their purport. Other jars, Nos. 14,—15, 16, 17, 18,—19, and 20, contained both substances mixed, and treated respectively with solutions of Ammonia, Nitric Acid, and Hydrochloric Acid: the Ammonia

to induce organic decomposition, the Nitric Acid because of its intimate relation to both substances, and Hydrochloric Acid for several chemical and accidental reasons. Besides the contents of the jars, several grains and cakes of compensating-powder, carefully made and in various conditions, were correspondingly treated. These jars and cakes were securely placed upon a glass-covered shelf outside the laboratory window, and left exposed to the alternate action of sun[1] and cold (freezing and thawing), for the space of nearly six months.

On the 23d of the following February they were again taken into the laboratory, and with Prof. Gœssmann's valuable aid, carefully re-examined and tested. The contents of jars Nos. 1 to 8 inclusive, containing the separated substances, were found to be unaltered. They were still neutral to fresh litmus paper; pieces of blue and red paper had in some cases remained unaltered side by side in the same jar during the entire period. Solutions of all of them were carefully filtered, and then treated with Barium-chloride as a test for sulphuric acid, a faint trace of which existed in the powder solutions, and was judged to be inherent in the sulphur, the latter being very retentive of this acid, and fresh powder giving the same reaction. The contents of jars Nos. 9 to 13 inclusive, were likewise found unaltered. This was the crucial part of the chemical investigation, for in this set of jars the two substances were mixed, and under conditions as disadvantageous to constancy as could fairly have been required. They were still neutral to litmus, gave the same clouds in the Barium-chloride test, obviously for the same reason, and when further specially tested for nitric acid, by the indigo and heat reaction, showed conclusively it was not present. In jar No. 14, ammonia was still present, the solution responded to the Barium-chloride test, and a few drops upon platinum left, when evaporated over an alcohol flame, faint traces of ammoniacal compounds—evidently the result of a decomposition induced by the ammonia. In jars Nos. 15, 16, 17, and 18, litmus paper showed that acid was still present, and the indigo test proved it to be nitric acid, as was naturally to be expected. This acid had to some extent acted destructively upon the substances, as proved by evaporation over an alcohol flame, and the solution still precipitated a cloud from Barium-chloride. Jars Nos. 19 and 20, which had been treated with the Hydrochloric acid, gave similar results to the tests.

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[1] Sometimes erroneously supposed to *induce* spontaneous action.

The cakes corresponding to the various jars acted in a respectively similar manner. Of course in the various cases where powder had been moistened there was an efflorescence of its nitre (the powder was mechanically ruined), but in all cases only the chemical actions were noted. Samples of these substances, as they came from the tests, were dried, and found to be still explosive.

From these severe experiments it is fair to conclude, that under all the ordinary circumstances of exposure, to which an explosive used for artillery purposes is liable to be subjected, this form of compensating-powder will undergo no chemical change attributable to the mutual action of gunpowder and gun-cotton—*in other words, it will preserve its virtue as reliably as either of the constituents.*

While awaiting the result of these chemical experiments, two other series were instituted, one with a view to examine the mechanical difficulties of the manufacture of compensating-powder, and the other to determine its action. Of course they were crude, for both of the investigations were attended with most serious drawbacks, owing to the almost entire lack of proper facilities, and therefore every allowance must be made where they do not fully justify theoretical expectations. These experiments were likewise carried on in the Military Department of the State College, and in them considerable assistance was lent by several members of the Senior class, especially by Cadet J. K. Mills, of Missouri.

The first cakes made were cubical, two inches on an edge, the interior core being cylindrical, one inch high and one inch in diameter. This size and form for the outer case were chosen because they very nearly approached those of the powder grains used in the 81-ton gun.[1] The form of the interior core was simply an adaptation to circumstances; the cotton had been kindly donated by Capt. Breese of the Torpedo Station, and that employed in these cakes was already in this form, it being the best imported Abel disk.

Several cakes were successfully made of this size and shape, but it was soon necessary to abandon the attempt because the press and dies were of wood, and though carefully made and shellac-polished, swelled

[1] The powder used in the 81-ton gun is understood to be cubical and 1·75 inches on an edge. This suggested the size for the first grains of compensating-powder, but the dimensions were taken somewhat larger so as to reduce still more the first strain upon the gun, and also give the core as great a capacity as possible, for convenience in manufacture.

badly and delayed the work; also the pressure needed for so large a grain was too great for the only machine at hand, merely a large-sized joiner's clamp.

A steel press with dies was then procured from the Holyoke machine company. It was capable of making spherical grains one inch in diameter, with spherical cores of half an inch diameter. It worked admirably, and with it quite a number of grains were manufactured and their characteristics studied. We shall not detail these, nor refer minutely to the difficulties which offered themselves, and the means that were taken or suggested to overcome them. The experiments showed, however, that the powder was entirely practicable as a mechanical possibility, and suggested several ways to carry on its manufacture so as to satisfy the demands of a war footing. It may be remarked here, in passing, that wherever utility makes a necessity, invention will find the means, and that the same demand which makes an envelope-machine cheap and valuable at $80,000, will not hesitate at the simple devices necessary to produce this powder.

Of course the decisive test in a programme of such experiments is to *fire* the powder in heavy guns and with full working charges. We certainly have the *power* if we can only *harness* it, and the idea seems to be so very near to what is desirable, *that its accomplishment must be possible.*

It once puzzled a king of England to know how an apple was introduced into a dumpling. It was simply an old housewife's secret, yet 'tis said the royal family experimented weeks at dumpling manufacture, to the amusement of the realm.—"*The proof is in the eating,*" *and it was the good eating of the dumpling that made the secret of its construction worth finding out.* But the main proof of this powder is in the firing; if this bears out the premises of theory, then the secret of its manufacture will be well worth our study, even if Uncle Sam himself has to soil his fingers with the dough.

From what has gone before it will be gathered that the name *compensating*, by which we distinguish this powder, is derived from two considerations: first, the grain is *built up* in such a manner that an interior core of higher explosive quality shall *compensate* for what would be wasted in a homogeneous powder charge; second, the explosion of this interior core is expected to fill up the increasing space

in rear of the projectile—in other words, to *compensate* for the diminished intensity of the powder-gas due to this increase.*

From the theory of its construction it is intended that every pound of it shall be an *efficient* pound. In compensating a hundred-pound powder charge, for its waste of 60 pounds, we may pursue one of several methods; three of these are worthy of present notice.

Fifteen pounds of gun-cotton are equivalent to at least 60 of powder. We may introduce this cotton at its maximum density, as a core into the 40 working pounds of powder. But if the powder, too, be kept at its maximum density, then, since we have the same number of spheres, but only 55 pounds against the original 100, the resulting spheres would be too small, hence the density of the powder must be reduced so that the size of the sphere may be kept constant.

A second method would be to mechanically adulterate the 15 pounds of gun-cotton with 45 pounds of *ordinary* cotton; we *might* then get a core the equivalent in power, and occupying the original space, of the 60 pounds of powder; surrounding this with the 40 working pounds of powder, at its maximum density, our resulting spheres would be of proper size and density, and to some extent compensated. The third expedient is to load the 40 pounds of powder with their full capacity—60 pounds—of gun-cotton. This would be distributed through about 1800 spheres and would have the force of some 280 effective pounds of powder. To obtain such a power from powder alone we would have to employ some 700 pounds—an amount that would more than half fill the 15-inch gun, and be as apt to burst it from its wadding action as from its ungovernable force.

Any of those methods may succeed, and all of them are worthy of trial, especially the latter. From some study, however, of the many bearings of the question, we are inclined to favor the first one, in a more or less modified form, as perhaps the most feasible. On the foregoing figure (JOURNAL OF THE FRANKLIN INSTITUTE, vol. civ, page 61) we have indicated the size capacity of a grain built up

* This idea may be expressed in a formula which shall apply to the granular construction of compensating-powder out of any two or more explosive substances, or out of the same substance in different conditions. Separate equations, for each case, may give the relative amounts of the various explosives required to compensate for waste, lack of force, increased space, etc., etc. The results, given by these formulæ, will depend upon the explosive force assigned to each constituent layer of the grain, and conversely to realize any required result, we must employ an explosive whose absolute force corresponds to it, as determined by calculation.

according to the requirements of this method. The one-half inch core of each sphere contains 58·3 grains of cotton at a considerable density; the jacket contains only 155·5 grains of powder; its density is therefore reduced, but its thickness and rate of combustion correspondingly increased. 55 pounds of this powder are spread through 1800 spheres, contain 40 efficient pounds of powder and 15 of gun-cotton, and occupy about the same space as a hundred-pound powder charge in the spherical form.

Let us estimate the force-capacity of a hundred-pound charge of this powder. It would contain some 27·2 pounds of gun-cotton and about 72·7 pounds of powder, which would be distributed through some 3272 spheres.[1] 27·2 pounds of cotton are equal to at least four times that amount of powder, or 108·8 pounds, which, added to the effective pounds of the powder-jacket, gives us an equivalent of 181·5 effective pounds of gunpowder. To obtain this amount from powder alone we would have to employ 453·75 pounds.[2] Comparing, then, a hundred-pound charge of compensator with one of hexagonal powder, we notice that from the former we gain 181·5 effective pounds, while from the latter we obtain but 40; a difference of 141·5 effective pounds in favor of the change, and the whole of which, let it be remembered, is to be expended *after the* 72 7-*pound powder-jacket* has done its best work upon the initial velocity. These figures are certainly startling, but let us examine the subject from another standpoint, and determine how much compensating-powder must be used to obtain the same effect that we now derive from the hundred-pound service-charge of the 15-inch gun. In other words, how much compensating-powder is required to equal 40 *efficient* pounds of powder.

Every 3·66 pounds of compensating-powder contain 2·66 pounds of powder and one pound of cotton; but the pound of cotton is equal to at least four pounds of powder; 6·66 is therefore the powder equivalency of 3·66 pounds of compensator. Dividing 40 by 6·66, we obtain 6, as the number of pounds of gun-cotton, and multiplying 6 by 2·66, we find 15·96, as the powder required to cover it. This gives 21·96, say 22 pounds, as the required amount: figures not perhaps so startling, but certainly as noticeable. This charge would contain only 719·8 spheres, would occupy but little more than one-

[1] The hundred-pound service-charge of Hexagonal powder contains from 8000 to 7200 distinct granules, and occupies a calibre's length, more or less, when in the 15-inch gun.

[2] See foot-note, Jour. Frank. Inst., civ. 63.

third the space of the present powder charge (both in the bore and *magazine*), would possess all its force, none of its waste, and be an *accelerator*.

It will not be excessively expensive to manufacture. It is considered that gun-cotton, made on a large scale, will be as cheap, if not cheaper, than powder, weight for weight; therefore all the extra expense may be charged to the grain construction.[1] The Government finds powder necessary at 25 cents a pound, even though the waste is over 60 pounds in every 100. It certainly cannot cost 25 dollars to manufacture 22 pounds of compensating-powder, and as 15·5 dollars of every 25 that we now spend for powder are a dead loss, we have an ample margin in which to make the venture worth trying. In this important sense, also, the powder may prove to be "*compensating*."

It will, perhaps, repay us to examine this proposed combination, and its constituent parts, under their chemical symbols.

The theoretical burning of gunpowder is expressed by the following equation:

$$2NO_3K + 3C + S = 3CO_2 + 2N + SK_2 \ldots\ldots\ldots\ldots (A).$$

The explosion of gun-cotton is given by the formula:

$$2C_6H_7(NO_2)_3O_5 = 3CO_2 + 9CO + 6N + 7OH_2 \ldots\ldots\ldots (B).$$

In the explosion of compensating-powder, the element *succession* is most noticeable. This is favorable to the stability of the several gases of its constituents when *brought together* under such peculiar conditions. The similar nature of the products of combustion of gunpowder and gun-cotton, seems to preclude any tendency (which very *dissimilar* gases might have) to result differently in combination than they do when separated. Hence we may simply combine these two reactions by addition, and obtain a legitimate expression for the explosion of compensating-powder, namely:

$$[2NO_3K + 3C + S] + [2C_6H_7(NO_2)_3O_5] = (3CO_2 + 3CO_2) + 9CO + (2N + 6N) + 7OH_2 + SK_2 = 6CO_2 + 9CO + 8N + 7OH_2 + SK_2 \ldots\ldots (C).$$

It is barely possible that the water in this reaction may be turned to account for the oxidation of the sulphide. But in this case *hydrogen*,

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[1] "Supposing quantities which would produce equal effects, then its cost (gun-cotton) is considerably less than that of gunpowder. Under ordinary circumstances, at a normal price for cotton, the cost of manufacture of gun-cotton is under fourteen pence per pound."—Baron Lenk before British Commission.—*Holley*.

a still more elastic gas, would be freed, and take the place of the steam. Such a variation would result in greater chemical action and therefore in the production of a higher temperature, all of which would finally be appreciated in ballistics as an accelerator.[f]

Comparing these reactions critically, we may obtain a very clear idea of the gas-capacity, and character, of the powder that will result from the combination proposed. It must be recalled in this comparison, that while the powder gases result from a progressive *combination* of its elements, those of the detonator come from its almost instantaneous *disintegration*. It is also to be noticed that the volume of the latter gases is many times greater than that of the former, and from the large amount of water it contains, that it has all the elasticity of steam.

It is claimed that gunpowder itself acts as an accelerator, from the fact that the great heat of its confined explosion must expedite the change into gas of its interior layers—just as a coal fire burns better and better until it reaches its maximum. This is obviously the case, though it is not an appreciable argument when offered against a combination that *is* a noticeable accelerator. This very feature, however, will work in favor of the compensating construction, for the accelerated burning of the powder-jacket will only be of importance during a very brief period, until the grain has become relatively small—beyond this point it is valueless; but the interior core, exploding at this same moment, will take up and carry to its climax this action, so well begun.[g]

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[f] From the mechanical nature of gunpowder we may vary its gaseous products to almost any extent, a feature which may perhaps be advantageously employed in the compensating construction.

Gun-cotton does not contain sufficient oxygen for the complete combustion of its carbon; this is shown by formula (B), where, though we find nine atoms of CO, we have only three of CO_2 To remedy this deficiency, some advantage might be gained by increasing the amount of nitre used in the powder jacket. *An excess* of oxygen in the powder products might thus be *made* to furnish sufficient to complete the *oxidation* of the interior core. Attempts, more or less successful, have already been made to nitrate or chlorate gun-cotton, with a view to supply this deficiency. The process is to soak the substance in saturated solutions of nitrates or chlorates.

[g] Commander Marvin, U. S. Navy, in his printed lecture on Granulations of Gunpowder, sums up the influences which determine the rate of consumption of powder grains as six in number.

1st. The purity of ingredients.

2d. The thoroughness of incorporation.

The experiments that were conducted to test the explosive action of the proposed combination, were the least comprehensive of the series. In so far, however, as could reasonably have been expected, they gave as satisfactory results as the others. No large guns were available for experiment, and so it was simply attempted to establish the fact that the combination would result as predicted. This was attended with considerable difficulty, as the only guns at hand were Springfield rifles.[1] It was utterly out of the question to try regular compensating-powder in these, and so resort was had to the following expedient.

A number of metallic-cases were carefully loaded as follows: Nos. 1 to 6 inclusive, contained the regulation charge of 60 grains of gunpowder; Nos. 7 to 9 inclusive, contained 20 grains of gun-cotton; Nos. 10 to 12 were loaded with 30 grains of powder and 10 grains of cotton each. Estimating gun-cotton at three times the force of gunpowder, Nos. 1 to 12 inclusive were severally equivalent to one

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3d. The specific gravity.

4th. The volume of the granule.

5th. The extent and *character* of the surface at the *initial*, *intermediate*, and *final* periods.

6th. The pressure under which combustion takes place.

So far as the first four and the last of these conditions are concerned, they may or may not be different in the case of compensating-powder, from what they are in that of hexagonal. Probably they will be the same, as the grain is to all intents and purposes *a powder grain during its first instants of combustion*. In the 5th condition, however, circumstances will have been considerably changed. This is the condition which specially concerns all compositions that pretend to be accelerative in their action. Examining the compensator in the light of this 5th consideration, we have in the initial period a large-grained charge of powder beginning its combustion, in the intermediate stage we find this powder combustion self-accelerating, and in the final one we have a charge of gun-cotton (more than equivalent to the powder already burned) detonating.

Just as we go to press, Ordnance Notes, No. 63 (on the 100-ton gun), reaches us. From page 1 we quote: "We may now add that the Italians have a powder of their own devising, called '*Progressive Powder*.' This is made in cubes, but the centre is less dense than the exterior so as to allow a more rapid combustion, as the cube burns away toward the centre." A snow-ball, from the very way in which it is made, is less dense on the interior than on the exterior; perhaps this—mere utilization of natural results—is the secret of manufacture of the Italian powder. Their idea is certainly good, but an old one in this country. We are ready now for an advancement in cannon powder. "All along the line" they seem to agree with us that we must have a "*compensating-powder*"—the only matters appears to be, *how* to make it.

[1] Cadet Model, Cal. ·50

of 60 grains of gunpowder, and theoretically were expected to accomplish the same work. Nos. 13 to 17 inclusive, were each loaded with 30 grains of powder, and amounts of cotton which ranged regularly up from 12 to 20 grains, the common difference in the progression being 2 grains. The powder equivalents of these charges were respectively 66, 72, 78, 84 and 90 grains. Finally, Nos. 19 and 20 contained 20 grains of powder and 20 of cotton each. Other shells were loaded with 30 grains of powder only, and still another set contained amounts of gun-cotton alone in charges of 2, 4, 6, 8 and 10 grains. A bullet weighing 550 grains was used with each charge, and in all the cases where powder and cotton were used in combination, save Nos. 19 and 20, the contents of the shell were arranged as follows: The powder was first introduced and pressed carefully home, the gun-cotton was then introduced as a wad, and to delay its ignition until the bullet should be moved, it was securely sealed in two thicknesses of thin oiled paper. In cases Nos. 19 and 20 no paper was used, but the cotton simply wadded down upon the powder. As no velocimeter was obtainable, the initial energy in the several cases had to be judged of from the penetration of the bullet. With a view to facilitate this, the target consisted of a strong box filled with pieces of inch plank placed in vertical juxtaposition against its ends. These were arranged so as to be easily withdrawn after each fire, for the purpose of tracing the course of the bullet. The rifle was secured to a wooden horse, was placed ten feet from the target, was discharged by means of a lanyard, and was carefully cleaned and oiled after each discharge.

The firings took place in the order of their numbers, and the first six gave a general and average penetration of 12 inches. At the 7th fire the rifle burst at the chamber, blowing the breech and stock to pieces, and driving a "*tumbling*" bullet through 13 inches of plank. Cartridges 8 and 9 were not fired for fear that they would result as No. 7 had. A new gun was put in place, and Nos. 10, 11 and 12 gave an average penetration of 14 inches. Nos. 13 to 17 (3 of each) gave a generally increasing penetration, varying from 13 to 20 inches. Under the action of No. 19, the second gun burst similarly to the first, although with more wreck, and the bullet lodged in the 9th plank. No. 20 was not fired. 30 grains of powder alone gave a penetration of 8 inches, and 2, 4, 6 and 8 grains of gun-cotton gave respectively 1, 3, 6 and 8 inches penetration.

Examining the results of the first 12 fires, we see that they agreed quite closely with calculations. The bursting of the first gun under charge No. 7 was rather expected, from the very nature of the charge, though its excellent penetration, under the circumstances, was somewhat of a surprise, and as an argument on the relative force of powder and cotton favors a higher estimate than 3 for the latter. The action of charges 10, 11 and 12 is regarded as a strong argument in favor of the compensating principle—they gave more than the requisite penetration, and since each contained but 30 grains of powder (and 10 of gun-cotton), the additional work (6 inches) must have been accomplished by the gun-cotton.[h] Charges Nos. 13 to 17 endorse this conclusion. The bursting of the second gun, under charge No. 19, was also natural. This charge was even greater than that of No. 7, and the lack of the oiled cover about the cotton must have caused the ignition of the two explosives at practically the same instant.

Other experiments and examinations were conducted with reference to these substances, and their combination, but they are minor to

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[h] The idea of starting a projectile by means of a charge of powder, and accelerating its velocity with gun-cotton or some other higher explosive, is by no means claimed to be new. Mechanical mixtures of powder and other explosives have been attempted, but have generally failed. In the explosion of such compounds, the more sensitive ingredient, especially if it be a detonator, is used up before the other has an opportunity to develop its energy, or else the weaker is lost in the more powerful action of the stronger. In a mere mixture the weaker substance may be said simply to adulterate the stronger.

A device was brought out some years ago in England, which consisted of a case containing powder surrounding a shorter interior one, of less diameter, filled with gun-cotton. A projectile, shouldered so that its base went a certain distance into the larger case, had a sub-calibre projection which penetrated for some distance further into the interior one. The action was to start the projectile with the powder gas; it was thus forced to take up sufficient motion to overcome inertia before its "tang" could leave the interior case, and the gun-cotton explode for purposes of acceleration. This contrivance was intended only for use in small arms, but while its test warranted the expense of patenting the complications in the manufacture, the small demand for the improvement in this form led to its abandonment for general purposes. We mention it here, as it bears directly upon the point which our third series of experiments goes to establish—namely, *that gun-cotton will accelerate the motion of a projectile which gunpowder has started.*

It is clear, too, that the method of combination which is proposed in the regular compensating grain is essentially different from this British attempt in the same direction. In the compensator, the powder itself is a jacket (or case) sufficiently strong and durable, certainly less expensive, and far more simple, than those just noticed.

these given above, and as our paper has already exceeded convenient length, we cannot notice them at present.

There are evidently many other explosive combinations, that offer fields of investigation as interesting as these that we have just studied. It may, perhaps, be found that some one of the Picrates, which are somewhat similar, in nature and composition, to gunpowder, but several times stronger, will act as a core in a compensating-cake, even better than gun-cotton. Or it may be found practicable to form charges for heavy guns out of a number of large, hollow grains, or out of boxes, so to speak, made of press-cake powder, and filled with fine-grained rifle powder. There would be no chemical objection to such a combination as the latter; it would certainly burn upon the accelerating principle, and would be mechanically possible; moreover it might be calculated with a view to eliminate powder waste.

Of course the experiments that we have sketched are not exhaustive, but they surely lend interest to the study of explosives. From the very nature, however, of such a subject, it is clear that vast means, delicate instruments, and special students, are necessary, to carry to their legitimate ends experiments of so much importance. Such facilities are possessed only by governments, and as the matter is of special value only for war purposes, it will undoubtedly enlist their attention.

The best guns of our day are "built up;" they are expensive, but certainly practical monuments to theory. Again, we study the circumstances of impact, and of trajectory motion, with a view to perfecting already elaborately made projectiles—"built up" projectiles. Why, then, should we not study the *motor-power* also from this same fruitful standpoint?

We may reasonably doubt that modern military science has no motor for the monster projectile more capable than gunpowder. It is one thing to assume this as the positive starting point of ballistics, but it is quite another, and not, perhaps, too radical a one, to approach this topic scientifically, and make *true* theory "build up" the agent that modern artillery demands.

We have practically perfected gunpowder, but the last great step in artillery—the great guns now on trial, the greater ones in prospect—requires a corresponding advance in explosives, a step which must consequently be taken in some new direction.

The near perfection of telegraphy did not prevent the possibility of the telephone, and if the latter redeems its promises, this instrument must supplant its worthy predecessor. The change from our present forms of gunpowder to a compensating-powder, would be similar to that from the telegraph to the telephone. In both cases improvement is the logical result of a similar line of study; in both of them we profit by experience, by the demands of necessity, and by the possibilities of mechanism. In neither do we discard the valuable and essential features of their predecessors, or make so radical a change as to render valueless our stock on hand.

Anæsthesia of Plants.—The vapors of chloroform paralyze the sensitive plant, in whatever position they find it, with the leaflets open or closed. M. P. Bert has found that chloroform or ether destroys the irritability without affecting the spontaneous movements. The result is the same when the plant is placed for some time in absolute darkness, while a continued light increases the irritability, and destroys the spontaneous movements. According to Pfeffer, the medial leaflets of a sensitive leaf may be paralyzed by an anæsthetic, without hindering the passage of irritation from the terminal leaflets to the base of the leaf, and thence to the neighboring leaves. M. Heckel has observed the action of anæsthetics on the stamens of barberries. He reports having produced a manifest sleep in branches plunged into 40 grains of water to which 3 grains of chloroform had been added, while chloral hydrate would not act unless it was changed into chloroform by the action of soda. But in this plant the anæsthesia occurs only in the position of repose. If the vapors of chloroform find the stamens raised against the pistil, they fall gently, and when they rest on the petals they are found to be asleep; irritations are without effect until this lethargic sleep is over. It is well known that ether and chloroform temporarily destroy the movements of protoplasm and of vibratile cilia. M. Mussat has described the contraction of the cellular plasmode, upon contact with chloral hydrate. Heckel has greatly lengthened the chloroform sleep of the barberry flower by introducing a drop of a concentrated aqueous solution of chlorhydrate of morphine.—*Les Mondes; Morren, Acad. roy. de Belgique.* C.

AN ECONOMICAL FORM OF GASHOLDER FOR THE LIME-LIGHT.

In the summer of 1875 the Franklin Institute determined to put in a pair of holders of considerable capacity for oxygen and hydrogen, so as to avoid the necessity of preparing the gases on each occasion that they were to be used, and other inconveniences in the use of bags and press-boards in connection with the lime-light. As it was desirable to use as great economy as was consistent with effectiveness and durability, the design shown in the accompanying illustration was adopted as covering these points.

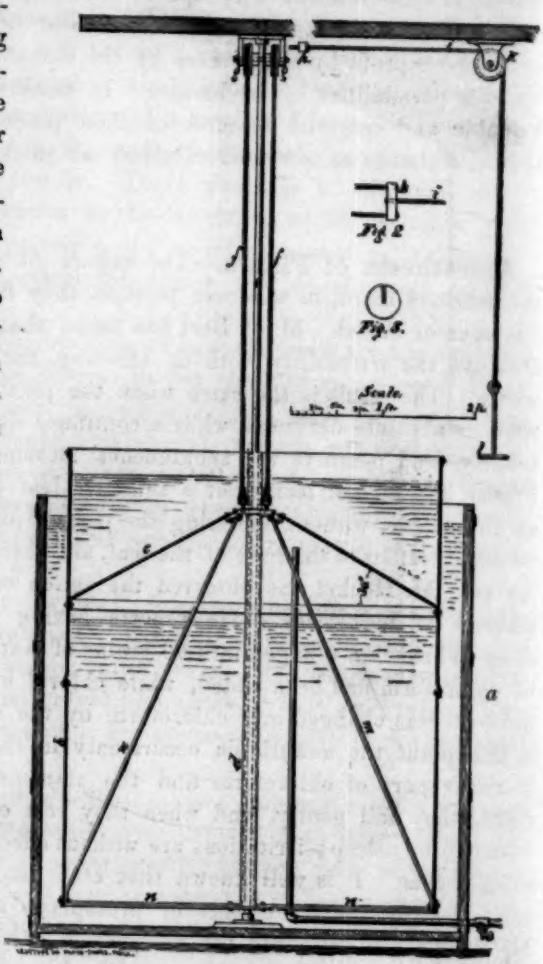

Fig. 1.

Fig. 1 is a sectional and Fig. 4 a perspective view. *A* represents a wooden tank or tub, 4½ feet in diameter, and 5 feet high, made of cedar wood, and hooped with iron in the usual manner; *b* represents the holder, made of No. 10 galvanized iron, and is 4 feet diameter by 5 feet high. The roof or top *c* is conical in shape, rising on each side at an angle of about 30°, and is attached to the sides of the holder 18 inches below the top edge, thus forming a receptacle for

water to act as a weight to produce the required pressure when the gas is being used.

In the centre of the holder, and extending its extreme height, is placed the tube *d*, passing through and fastened by a water- and gas-tight joint to the roof *c*, and being held firmly in the centre at its lower end by the four braces *n*. The holder is given additional stiffness by the diagonal braces *m*, which, however, may be dispensed with in holders of this size or smaller. From the centre of the bottom of the wooden tank, rises a bar or post of 1 in. round iron, passing through the tube *d*, and reaching to the ceiling of the room, thus forming a simple and almost frictionless guide for the holder in its vertical movements.

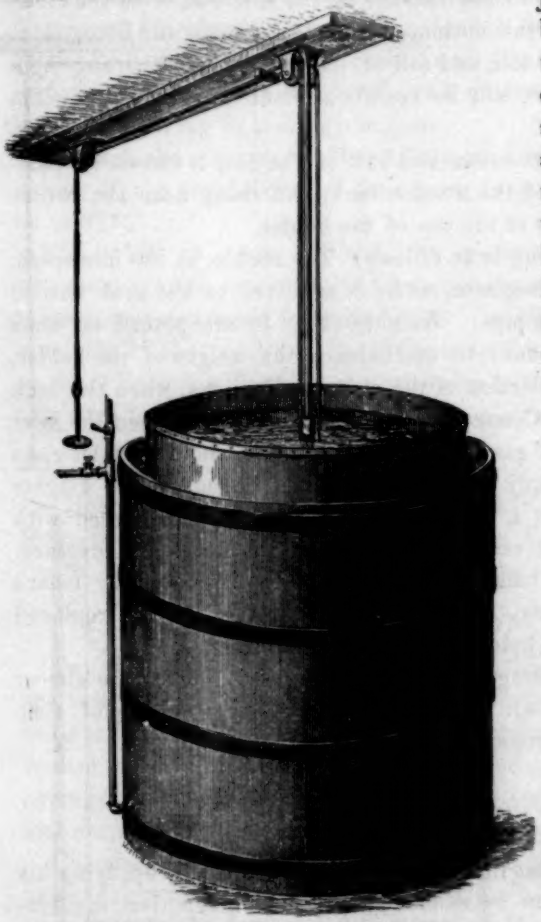

Fig. 4.

On either side of the tube *d*, and as near as convenient, are placed two eye-bolts, from which are carried wire cords *f f*, up to and over the pulleys *g g*. After passing these pulleys or shrives a few inches (the holder being at its lowest point), the ends of the cords are inserted and fastened in holes in the crossbar *h*, as shown in Fig. 2. Midway between these cords is inserted from the opposite side of the crossbar, a single cord, as is also shown in Fig. 2, as well as in Fig. 4, which

represents this portion broken off and swinging around at a right angle to its proper position. This cord *i* passes over the shrive *k*, and extends down to within a convenient distance of the floor, and has attached to its extremity the pan *l*, for holding the weight shown in Fig. 3. Care must be taken that the distance of the shrive *k*, from the cross-bar *h*, and also from the bottom of the scale pan to the floor, is as great as the proposed rise and fall of the holder. The arrangement of cords, shrives, etc., will be readily seen in the perspective view, Fig. 4.

The pipe for the admission and exit of the gas, is shown as passing through the side of the wooden tank, and rising near the centre to within a few inches of the top of the holder.

The manner of using is as follows: The cock *o*, in the inlet pipe, being open to the atmosphere, water is admitted to the tank until it rises to the top of the pipe. Weights (Fig. 3) are placed on scale pan *l*, in sufficient amount to overbalance the weight of the holder, and to overcome the friction of the cords and pulleys, when the cock *o* should be closed. Communication being opened between the inlet pipe and the source of gas supply, the gas enters, and the holder rises until filled. The supply of gas should then be cut off, the weights removed from the pan *l*, the space at the top of holder filled with water, and the gas is ready for use, under the necessary pressure. When the holder is exhausted, the water on top is run off by means of an india-rubber tube, acting as a siphon, the weights replaced on the pan, and the holder is ready for refilling.

Where the oxy-hydrogen light is much used, holders are almost indispensable, and in all cases they effect a large saving of time and material in the preparation and use of the gases. K.

Sun-Spots and Magnetism.—Prof. Wolf finds, by applying his formula for the relation between sun-spots and magnetism, a calculated value of 6·40′ for the mean variation of declination at Prague. The observed value was 6·47′, an agreement which he justly regards as marvelous. He believes the mean sun-spot period to be $11\frac{1}{9}$ years, but there are strong indications of a grand period of 178 years, embracing 16 solar periods of $11\frac{1}{9}$ years, and 15 revolutions of Jupiter. *Les Mondes*, April 5. C.

TESTS OF STATIONARY STEAM BOILERS AT THE CENTENNIAL.

The report of Mr. E. M. Hugentobler, expert in charge of the steam boiler tests at the Centennial, to Mr. John S. Albert, Chief of the Bureau of Machinery, is now going through the press, and will cover about 200 octavo pages. It contains all the logs or records of observation, taken with much detail, and otherwise bears evidence of much painstaking in making the tests.

Through the courtesy of Mr. Albert, we have been furnished with a copy of the proof-sheets of the report, from which the following is an extract.

The tables on pages 108 and 109, containing some of the more important results, are compiled from more extended tables, of which there is a separate one for each boiler. In these latter there is also a column of the results of the "Capacity Test" of each boiler, but as the "Economy Test" is of more value to the steam user, only the last need be given here. K.

Fourteen boilers were tested in the order named: the Wiegand, the Harrison, the Firmenich, the Rogers & Black, the Andrews, the Root, the Kelly, the Exeter, the Lowe, the Babcock & Wilcox, the Smith, the Galloway, the Anderson, and the Pierce boilers.

NATURE OF THE TESTS.

Two tests, each of eight hours' duration, were made of each boiler; the first with full natural draft and clean fires to determine the potential evaporation, the second with fires regulated to burn about three-fourths as much coal as before, or, in other words, to approximate average working conditions with a view of ascertaining the economical evaporation.

Calorimeter observations of the quality of the steam were taken at stated intervals during all the tests, and have been taken into account in computing the results of the several trials.

During all the trials a steam-pressure of seventy pounds was regularly maintained on the boilers by adjusting the stop-valves; a steam-gauge was attached on the steam-pipe just below the stop-valve, and a man was stationed at all times on top of the boiler to watch the gauge and regulate the valve accordingly.

Before beginning an experiment, steam was raised to seventy pounds, when the stop-valve was closed, fires hauled, and ash-pits cleaned. As soon as new fires could be established with weighed wood and coal, the water-level was noted (with fire-doors closed and fires burning), after which the stop-valve was opened; the time of opening the valve being recorded as the time of starting the test. After steaming for eight hours the stop-valve was closed and the water-level again noted (with fire-doors closed); the fires were then hauled and extinguished, and the ash-pits cleaned out.

All the coal and kindling wood, estimated at its equivalent in coal, consumed for starting and maintaining new fires, were charged to the boiler, and all the water pumped into the boiler to maintain the level at the same height was credited to the boiler as evaporated, subject to corrections indicated by calorimeter, as explained below.

In the two tests of the Kelly boiler, the economy trial of the Exeter, and the economy trial of the Babcock & Wilcox boilers, the level at stopping was higher than at starting; and for those tests the amounts of water corresponding to the differences in level have been deducted from the amounts pumped into those boilers. In all other cases, however, the level at stopping was the same as at starting, or when lower a few strokes of the pump would bring it up to the required point, the water thus pumped being of course credited to the boiler as having been evaporated.

In all cases precautions were taken to trace all connections to the boiler on trial, to see that they were tight; and all blow-off pipes were disconnected, so as to detect any leak that might occur through the blow-off valves. In two or three instances slight leaks occurred, but all the water was collected and deducted from the amount fed into the boiler.

Before starting, the approximate amount of coal needed for the trial was weighed out of the coal-bin and dumped in a separate pile on the floor, away from all other coals. From this pile coal was taken in barrows as required for running the test, and the weight of each barrow-load noted. This plan of keeping two separate accounts of the coal removed all chance of error in the amount of coal actually consumed, as at the close of each experiment the two accounts were balanced, and any error would have been detected at once. The second coal account has been taken as the basis for calculating the evaporation, adding to it, of course, the equivalent of the kindling

wood, which was taken at the rate of 0·40 pound of coal per pound of wood.

Upon completing a trial, fires were hauled and extinguished as rapidly as possible, the grates and ash-pits carefully cleaned, and all the coal, ashes and clinkers hauled from under the boiler were sifted. The coal was carefully picked by hand and weighed separately. This amount of coal deducted from the amount of coal fired on the grates gives the amount of coal actually consumed. By deducting from the latter the amount of refuse (ashes and clinkers), the amount of combustible consumed was determined.

The feed-water measuring apparatus consisted of two metallic tanks placed on separate platform scales, with provision for filling from the hydrant. A Blake double-plunger feed-pump, supplied with steam from the boiler on trial, was placed between the tanks, and its suction-pipe was provided with a rubber hose, whereby the pump could be made to take water at will from either tank. This pump was used on all the trials, and whenever it was attached to a new boiler, precaution was taken to see that the feed-pipe was tight, and that all other connections of the boiler to other pumps or injectors were broken off.

After filling a tank with water from the hydrant, its gross weight was noted, and after it had been pumped out almost dry, the suction-hose of the pump was shifted to tank No. 2 (previously filled and weighed), and the gross tare of tank No. 1 was taken; the difference between the gross initial weight and the gross tare being the net weight of water pumped into the boiler. Tank No. 1 was then refilled and its gross weight again noted, when it stood ready to supply the pump as soon as tank No. 2 should be emptied.

The temperature of the feed-water was observed twice in each of the tanks. In the logs will be found the gross weights and gross tares of the tank, together with the times at which hose was shifted, and the heights of water in the boiler at those times, also the temperatures of feed-water. The measurements of the feed-water and the running of the pump were intrusted to one assistant.

Another assistant had charge of the coal accounts, and also took half-hourly observations of the temperatures of the outside air, of the fire-room, steam, pyrometer, water-level, and steam-pressure. This latter observation was taken from the gauge mentioned above, attached just below the stop-valve. A recording gauge was also attached to

RESULTS OF THE

Name of Boiler.	Average steam pressure in boiler, above atmosphere.	Average temperature of steam.	Average temperature of uptake.	Average temperature of feed water.	Average amount of coal consumed per sq. foot of grate per hour.	Number of pounds of water actually evaporated per pound of coal.	Number of pounds of water actually evaporated per pound of combustible.
Wiegand, . . .	70·029	313·17	523·81	70·80	12·32	8·219	9·097
Harrison, . . .	70·03	310·76	517·50	71·16	12·30	8·036	8·785
Firmenich, . .	70·059	356·17	415·50	68·95	11·79	8·927	9·956
Rogers & Black,	70·30	309·76	571·75	67·11	.....	7·266	8·059
Andrews, . . .	70·059	328·47	419·60	65·44	8·05	7·985	8·904
Root, ...	69·94	312·50	393·33	64·59	9·09	8·889	9·930
Kelly, ...	69·95	310·00	.....	66·95	10 82	7·858	8·636
Exeter, . . .	70·00	308·00	429·94	68·93	9·35	7·276	8·213
Lowe, ...	70·00	309·00	332·29	66·44	6·805	8·758	9·873
Babcock & Wilcox	70·00	389·06	295·82	63·98	9·77	8·812	8·908
Smith,[1] . . .	.....	.....	.....	.....	.....	.....	.....
Galloway, . .	70·06	310·06	303·00	55·95	8·87	8·514	9·580
Galloway,[ii] . .	70·12	310·06	324·62	55·12	7·269	9·182	10·069
Anderson, . .	70·00	322·75	417·00	54·00	9·747	7·918	8·727
Pierce, . . .	70·00	312·94	373·82	53·20	7·99	7·419	8·336

[1] No Table of Results of the Smith Boiler was furnished.

[ii] This test was made with Bituminous Coal.

TESTS FOR ECONOMY.

Average actual amount of water evaporated per hour. Pounds.	Number of pounds of water actually evaporated per sq. foot of heating surface, per hour.	Percentage of moisture in steam.	Number of degrees superheated (steam).	Number of lbs. of saturated steam evaporated at 70 lbs. from 212° equivalent to total heat units derived from the fuel.			Rating of boiler on the basis of 12½ sq. feet of heating surface per horse-power.	Rating of boiler on the basis of 30 lbs. of water actually evaporated per horse-power, per hour.
				Per pound of coal.	Per pound of combustible.	Per sq. ft. of heating surface per hr.		
4255·36	3·14	.....	13·40	9·463	10·461	3·618	108·40	141·85
2285·73	2·532	1·11	.....	9·167	10·022	2·894	72·06	76·19
1654·20	1·533	.....	26·70	10·340	11·530	1·775	86·31	55·14
1320·57	3·30	2·68	.....	8·397	9·313	3·810	31·98	44·019
1183·74	2·19	.....	52·59	9·428	10·513	2·590	43·20	39·46
3393·33	2·217	.....	23·16	10·852	11·565	2·485	127·20	113·11
2338·56	3·532	5·97	.....	9·189	10·099	4·131	52·96	7·795
2041·70	1·338	4·63	.....	8·643	9·756	1·589	122·04	68·06
1341·18	1·731	.....	1·05	10·190	11·489	2·014	61·97	44·71
3919·81	2·33	3·24	.....	10·211	11·489	2·701	134·40	130·66
.....	.....	.....	.....	.....	.....	.....	.....	.....
2945·71	3·026	0·22	.....	9·942	11·187	3·533	77·88	98·19
2603·02	2·673	0·57	.....	10·689	11·720	3·113	77·88	86·77
2778·81	2·448	.....	14·88	9·305	10·255	2·877	90·08	92·63
1484·61	7·406	5·53	.....	8·738	9·818	8·714	16·03	39·48

the boiler, and served to detect any negligence on the part of the man stationed on top of the boiler to regulate pressure. The barometric pressures given in the logs were not observed in the fire-room. Necessary data were kindly furnished by the Signal Station, U. S. A., and proper corrections were made for level and temperature.

The records of the temperature of steam, as shown in the logs and given by a mercury thermometer, are undoubtedly too low. I found that in certain cases, when a draft would blow over the boiler, the simple fact of covering the stem of the thermometer would cause the mercury to rise 10 or 15 degrees. However, it may be seen that, although the temperatures shown by thermometer fall short of the temperatures indicated by calorimeter, the variations in both sets of records correspond.

COAL AND FIRING.

The coal used in all the trials was anthracite coal from the Lea Colliery, Wilkesbarre, Pennsylvania, and was the same as was supplied regularly to the Bureau of Machinery; it was nearly all uniform in size; in quality it varied somewhat, as shown in the following table:

Percentage of Refuse from Coal.

	Capacity Test.	Economy Test.		Capacity Test.	Economy Test.
Wiegand, . .	8·487	9·537	Exeter, . .	9·265	11·405
Harrison, .	8·369	8·526	Lowe, . .	10·640	11·286
Firmenich, . .	8·625	10·338	Babcock & Wilcox,	7·845	10·237
Rogers & Black,	8·373	9·835	Galloway, .	11·055	11·128
Andrews, . .	9·428	10·319	Anderson, .	8·684	9·261
Root, . . .	9·67	10·48	Pierce, . .	8·401	11·600
Kelly, . .	8·67	9·01			

The coal for the trials was by no means selected or picked, but taken as it came, the prevailing object throughout the test being to get at average working conditions.

The two regular trials for economy and capacity were repeated on the Galloway boiler with bituminous coal, that boiler being proportioned for that kind of fuel. The coal used was George's Creek bituminous coal; it was of very fair quality, but necessitated constant attention to the fires, as it ran and caked very freely on the grates.

The firing was left entirely to the judgment of the exhibitors and their men.

CALORIMETRIC OBSERVATIONS.

Of the several methods for ascertaining the amount of water carried over with steam from a boiler, the calorimetric investigation of the quality of steam, first applied in 1859 by Prof. G. A. Hirn, is the most simple, the most direct, and the most accurate. At the same time it is so practical that it should certainly come into general use. The principle of this method is to condense a certain weight of steam in a given weight of water contained in a vessel, the temperature of which is thereby increased; the number of heat units imparted to the water (its weight multiplied by the increase in temperature) represents the amount of heat liberated by the steam in condensing, and then cooling down to the temperature at which both the water originally in the tank and that formed by the condensed steam stand at the end of the operation.

In these tests the calorimeter consisted of a plain wooden barrel, provided with a suitable stirring apparatus, and placed on a platform scale; a drain-pipe was attached to the bottom of the barrel, and provision was made for filling the barrel with water from the hydrant. Into a vertical portion of the steam-pipe of the boiler, and close to and below the stop-valve, was screwed a short horizontal piece of $\frac{3}{4}$-inch pipe, which was screwed in until it touched the opposite side of the steam-pipe. A row of small holes was drilled on one side of the $\frac{3}{4}$-inch nipple, and in attaching it care was taken that the holes should be turned downward, the object of this contrivance being to catch steam from all the portions of the ascending stream in the steam-pipe. To the $\frac{3}{4}$-inch nipple was attached a $\frac{3}{4}$-inch pipe, felted throughout its length, and running to within a couple of feet of the calorimeter barrel. At the end of this pipe was attached a $\frac{1}{2}$-inch globe valve, and beyond that was fastened a 1-inch hose about five feet long. The observations were taken every twenty minutes in the following manner: The barrel was filled with water from the hydrant, and the gross weight and the temperature were noted. The globe valve on the $\frac{3}{4}$-inch steam-pipe was opened just enough to puff out all water which might have collected in the pipe; then the end of the hose was dipped in the water in the barrel, and the globe valve opened wide. At the same time a signal was given with a gong for the man on top of the boiler to note the steam-pressure. The water was agitated in the calorimeter barrel so as to insure a thorough distribution of the heat throughout the mass of water. When the

temperature in the barrel had been raised sufficiently, the globe valve was closed; the signal was repeated for the man on top of the boiler to note the steam-pressure again, and the temperature of the water in the barrel was carefully observed; then, after taking the hose out of the water, and letting drip from it into the barrel all water which might have been lifted with it, the final gross weight was taken, the increase in weight representing the steam (with water primed, if any) brought into the barrel.

During the progress of a calorimetric observation the man on the top of the boiler was not allowed to touch the stop-valve, in order to prevent changing the conditions of steam.

The duration of the calorimetric experiments varied somewhat. It was attempted as a rule to reach a final temperature in the barrel as many degrees above the temperature of the surrounding atmosphere as the initial temperature was below, the object being to compensate for loss and absorption of heat through the surface.

All things being equal, the duration of the experiment was governed by the quality of steam, as the hotter the steam the less time it would take to heat the contents of the barrel. This may seem useless to mention, still, it showed the sensitiveness of the apparatus.

The calorimeter data are given in the logs. The weight of the barrel is also given; it is the mean of two weighings at the beginning and the end of the trial. An allowance has been made, in computing the results, for the iron stirring apparatus in the barrel, which has to be heated every time, with the water. The weight of the stirrer, multiplied by the specific heat of iron, has been added in all cases to the net amount of water heated.

A New Washing Fluid.—Beat 1 kilogramme of soap, with a little water, into a paste, warm it moderately, and incorporate it, by thorough stirring, into 45 litres of water at a temperature of about 30° C. (86° F.), to which 1 tablespoonful of oil of turpentine and 2 tablespoonfuls of ammonia have been added. The articles to be washed are to be soaked in this mixture for two hours, and then washed as usual. The fluid can be rewarmed and used a second time, by adding more turpentine and ammonia. The process is said to be time, labor and money-saving, much less soap and rubbing being needed, and the wear of the clothes is greatly diminished.—*Neueste Erfind. u. Erfahr.; Pap. Zeit.*, May 3. C.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. civ, page 48.]

P. W. Hofmann[ii] communicated to the German Chemical Society, that if sulphurous acid is conducted into sulphuric acid, saturated with nitric acid, and of the sp. gr. 1·7, the nitric acid is reduced to compounds which combine with the concentrated sulphuric acid present to form the so-called chamber crystals, without the production of appreciable quantities of nitrous oxide. A different behavior was observed if the acid saturated with nitric acid has, *e. g.*, the sp. gr. 1·5, instead of 1·7. In this case the sulphurous acid attacks the nitric acid more profoundly, and there is formed a not unimportant quantity of nitrogen, or—which for the sulphuric acid maker is practically the same thing—of nitrous oxide. The explanation must doubtless be sought in the fact that in the latter case no concentrated sulphuric acid is present with which the higher oxides of nitrogen might unite to form chamber crystals. These facts having been established he sought to turn them to account in the manufacture of sulphuric acid as follows:

In the first chamber he diminished the jet of steam in such a manner that only acid of sp. gr. 1·7 was produced, and he found the laboratory experiments confirmed in such a manner that a much smaller quantity of nitric acid was needful for an equal amount of sulphuric acid. If the precaution is observed that whenever the sp. gr. of the chamber acid incidentally falls, it is raised again to 1·7 by the addition of monohydrated acid, a reduction of the consumption of nitric acid is effected to the extent of 1 kilo. per 100 kilos. sulphur.

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[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

[ii] P. W. Hofmann, *Ber. Chem. Gesell.*, 1870, 5.

In the *Chemical News*[1] the proposal of P. W. Hofmann, to which reference has been made, has been discussed at length by Gibbons, Peter Spence, and others, and the process has been already experimentally introduced into certain German establishments. In 1867 Winckler[ii] published some interesting investigations on the chemical processes which take place in the Gay-Lussac condensing towers. The following conclusions may be drawn from his experiments:

a. Nitric oxide is not absorbed by hydrated sulphuric acid.

b. Hydrated sulphuric acid combines with nitrous acid energetically and with the evolution of heat. The compound is intimate and truly chemical; it is not decomposed by a considerable elevation of temperature, but is immediately broken up on the addition of water. In the manufacture of sulphuric acid this compound is formed in a solid state in the so-called chamber crystals, whilst it is met with dissolved in a liquid state in the sulphuric acid flowing out of the coke towers of Gay-Lussac's apparatus. Nitric oxide and oxygen do not, in presence of hydrated sulphuric acid, combine as usual to form hyponitric acid, but form nitrous acid, even when the oxygen is in excess.

c. Hyponitric acid, both in the liquid and the gaseous condition, is capable of combining with the hydrated sulphuric acid. The compound, however, if truly chemical is very unstable. On the application of heat it is completely decomposed, and the hyponitric acid either escapes unchanged or is resolved into nitrous acid, which enters into chemical combination with the sulphuric acid, and into oxygen which is set free. The mode of decomposition depends on the degree of concentration of the sulphuric acid.

d. Sulphuric acid and nitric acid appear to form mere mechanical mixtures, which, when heated, are resolved into escaping nitric acid, oxygen gas, and nitrous sulphuric acid.

e. Nitrous sulphuric acid, in presence of moisture, forms, on contact, hydrated sulphuric acid, while nitric oxide gas is evolved.

f. Hyponitric acid, in contact with moist sulphurous acid, forms nitrous sulphuric acid in a solid crystalline state.

Ten years ago most sulphuric acid works were unprovided with the Gay-Lussac tower for absorbing the nitrous acid which escapes at the

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[1] *Chemical News*, 1870, pp. 106, 132, 141, 164, 189, 200, 212, 224.

[ii] Winckler, in the work cited.

end of the lead chambers. In many cases such a tower had been erected, but was not in use. Gay-Lussac, along with Lacroix, introduced his process at Chauny, in the department of Aisne, as early as 1842, in order to absorb the nitrogen compounds escaping from the chambers in concentrated sulphuric acid, and thus to make them capable of re-utilization. These experiments were undertaken, therefore, at a time when the acid was prepared almost exclusively from sulphur. In establishments where sulphur is in use, the evolution of the gas is generally regular, and hence at that time the results were satisfactory as regards the consumption of nitre. On the introduction of pyrites, especially when the original and imperfect kilns were employed, the influx of gas became less regular, the process in the chambers becoming thus liable to manifold disturbances. Gay-Lussac's apparatus therefore began to yield bad results. At the present day, since Gerstenhöfer and Schwarzenberg have calculated the composition of the kiln gases theoretically most advantageous, since we have learned to check over the composition of the gases by a simple determination of the sulphurous acid, and since more light has been thrown upon the whole process of the formation of sulphuric acid by the researches of Weber and Winckler, a regular production of gas is obtained from the pyrites kilns. The apparatus of Gay-Lussac was therefore introduced at Freiberg in 1865, and has been so managed that the results surpassed everything previously known as concerns the consumption of sulphuric acid. Gerstenhöfer has the merit of contributing to these successes, and of circulating the experience obtained at Freiberg. At Aussig, Liesing, Hautmont, Berlin, Brussels, Griesheim, Hanover, Stolberg, and elsewhere, Gay-Lussac's towers on the Freiberg pattern have been introduced. Since regular determinations of the sulphurous acid in the kiln gases have been made on Reich's method, and since the tower acid from Gay-Lussac's apparatus has been regularly tested for nitrous acid, as proposed by Winckler, a new era in the manufacture of sulphuric acid has been opened. The details of the apparatus as at first used in Freiberg have been given by Schwarzenberg,[1] who also describes the wheel first employed by Segner at Aussig, for the regular moistening of the coke in the towers.

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[1] "Handbuch der Chemischen Technologie," von P. Bolley, 2 Band, 1 Gruppe, von Dr. P. Schwarzenberg.

The decomposition of the nitrous sulphuric acid was formerly effected by steam in a so-called "boiling drum." As this apparatus requires frequent repairs, in some establishments the nitrous sulphuric acid is allowed to flow together with water in cascades of earthen vessels placed within the chamber, when the decomposition takes place. Recently Glover's tower, which will be described in the next section, has been used for this object with the best results. A mixture of chamber acid and nitrous sulphuric acid flows from Gay-Lussac's apparatus down into Glover's tower. The hot kiln gases enter from below and concentrate the sulphuric acid to sp. gr. 1·7. The aqueous vapors thus evolved with the aid of the sulphurous acid decompose the nitrous sulphuric acid so completely that the concentrated acid from Glover's tower is perfectly free from nitrogen compounds, whilst the decomposition in the boiling drum and with the cascade can hardly be so conducted, but that imperfectly decomposed acid now and then escapes.

As regards the construction of the chambers, opinions vary concerning the most advantageous form. A. W. Hofmann,[i] in the Report of the London Exhibition, pronounced the formation of sulphuric acid independent of surface action, a view confirmed by the experience of many old manufacturers. Stass[ii] has also proved by experiments at the chemical works of De Hemptine, at Brussels, that, other conditions being equal, the formation of sulphuric acid is proportional to the volume of the chambers. Smith,[iii] in the pamphlet which we have repeatedly quoted, maintains that the interior of the chambers is a still unexplored land, and as a contribution to its exploration he gives some interesting statements as to the proportion of sulphurous acid, nitric acid, and sulphuric acid present in the chamber gases. Among other points he finds that the formation of acid is greatest in the vicinity of the acid already formed, and considers himself justified in concluding that the best shape for chambers is a height of 3 metres, a width of 9, and a length of 60. The author has not found the views of Smith to hold good. He suspended leaden capsules of equal sizes at different heights in the chambers covered with lids at the height of 30 c.m. from each, and determined the amount of sulphuric acid formed in each in an equal time.

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[i] A. W. Hofmann, "Reports by the Juries," p. 99.

[ii] A. W. Hofmann, "Reports by the Juries," p. 14.

[iii] Smith, "Chemistry of Sulphuric Acid Manufacture," p. 22.

Smith has probably drawn gases out of the chamber by aspiration, and determined the sulphuric acid therein. It is plain that even if sulphuric acid is formed equally in all parts, the samples drawn below must contain a larger proportion of acid, since that which is formed in the higher part of the chamber must fall downwards. Smith seems, therefore, in this case not to have drawn the right conclusion from his observations.

From the production of sulphuric acid at different heights in the chamber, which for an equal cubic space was approximately equal, Hasenclever inferred that within certain limits, a chamber was the better the fewer square metres of sheet lead it required for a metre of cubic contents.

The lead chamber which Hasenclever has lately constructed for the Rhenania Chemical Works, near Stolberg, is 10 metres high, 10 broad, and 40 long, and requires, therefore, 0·45 square metre of sheet lead for a cubic metre of volume. In almost all earlier chambers the consumption of lead was greater.[1]

Calculation of the Yield of Acid.—As to the amount of real acid present in the aqueous sulphuric acid, several tables, more or less mutually discordant, are used in chemical works. In the recent manuals of Graham-Otto, Wagner, Bolley (Schwarzenberg), and others, the statements of Bineau have been adopted as the most accurate. But in many manufactories calculations are still based on the earlier statements of Vanquelin, d'Arcet, Dalton, and Ure. In drawing up the latter tables, it is assumed that the sulphuric acid of commerce at 66° B. is not a pure hydrate, but contains, at sp. gr. 1·830, 6 to 7 per cent. of water more than H_2SO_4. Latterly Kolb[ii] has published detailed and accurate investigations on the proportion

[1] In connection with the author's communications on the process in the chambers, we mention the recent proposal of Sprengel (English patent No. 3189, A.D. 1873) to supply the chamber with pulverized water instead of with steam. The water in the interior of the chamber is converted into a mist by forcing air or steam into a stream of water. The apparatus by which this comminution of the water is effected, is founded on the same principle as the "*pulverisateur*" used in medicine, or the "*refraichisseur*" of the perfumers, known in England as the "atomizer." The advantage of the introduction of pulverized water is, chiefly, an economy in fuel. According to reports which have reached the Editor, this water-dust has been already advantageously introduced in several establishments. In works which employ the Glover tower this improvement is of little value.—A. W. H.

[ii] J. Kolb, *Bull. Industr. de Mulhouse*, Feb. 28, 1872.

of monohydrate in acids of different specific gravities, which in a great measure confirm the statements of Bineau. The discrepancy which has hitherto prevailed in this respect, depends not on the unequal proportions shown by different tables, but on the unequal graduation of the Beaumé hydrometers. Gerlach[i] has given an interesting conspectus of the specific gravities answering to the single degrees of the scale hydrometer.

As in sulphuric acid works Beaumé's scale is chiefly employed,[ii] a concordant graduation of this hydrometer is much to be desired. Kolb in his tables has introduced a new graduation, since adopted by many, where 0° B. = the sp. gr. of water at 15° C., and 66° B. = the sp. gr. of monohydrated sulphuric acid at 15° C. (= 1·842). The relation between Beaumé and specific gravity is consequently expressed by the equation

$$d = \frac{144{\cdot}3}{144{\cdot}3 - n},$$

d expressing the sp. gr. and n the degree of Beaumé.[iii]

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[i] Gerlach, *Dingl. Pol. Journ.*, cxcviii, 313.

[ii] This, of course, refers only to the continent.—Ed. *C. N.*

[iii] As Beaumé's hydrometer is still almost exclusively used in chemical manufactures, the above formula, especially for laboratory use, is of considerable interest, and a closer investigation of its origin may not be unremunerative. If a hydrometer sinks in water to 0°, in another liquid D, of the sp. gr. d, only to n°, the two unequal volumes of displaced liquid have each the same weight, *i. e.*, the weight of the hydrometer. If we call the weight of this hydrometer G—the weight of a volume of water corresponding to the volume of a degree of the scale being taken as unity—we have the weight of the volume of water displaced by the hydrometer = G; the weight of an equal volume of the liquid D of sp. gr. d = G d; the weight of the water displaced by n degrees of the scale = n; the weight of an equal volume of D = $n\,d$. This latter weight is the difference between the weights G d and G, and we have therefore

$$\mathrm{G}\,d - \mathrm{G} = n\,d;\ \text{whence}\ d = \frac{\mathrm{G}}{\mathrm{G} - n}\ \text{and}\ \mathrm{G} = \frac{n\,d}{d - 1}.$$

For the case of monohydrated sulphuric acid of sp. gr. 1·842 in which at 15° C. Beaumé's hydrometer sinks to 66°, we substitute these values in the last formula for d and n, and for G we put the number 144·3, and we have then—

$$d = \frac{144{\cdot}3}{144{\cdot}3 - n}.$$

The number 144·3 represents the weight of the hydrometer if the weight of the volume of water corresponding to the volume of a degree of the scale is taken as unity.—A. W. H.

It would be highly desirable if all manufacturers of sulphuric acid would base their calculations on the same tables, for in statements on the yield of sulphuric acid at 66° B. from pyrites or sulphur, different tables are often used, so that the results of different works are not directly comparable.

The following conspectus of the statements of different tables may be of interest in this respect.[1]

Degree of Beaumé.	Sp.Gr. according to Kolb.	Proportion of Monohydrate according to Tables of Various Works.							
		Vanquelin.	d'Arcet.					Bineau.	Kolb.
10	1·075	11·73	—	11·5	11·40	—	10·98	11·0	10·8
20	1·162	24·01	—	23·3	23·46	—	21·97	22·4	22·2
30	1·263	36·52	—	36·9	36·60	—	35·93	34·9	34·7
40	1·383	50·41	—	51·6	51·49	—	49·94	48·4	48·3
50	1·530	66·54	66·45	66·9	66·17	63·8	63·92	62·7	62·5
60	1·711	84·22	82·34	83·3	82·80	79·4	79·90	78·0	78·1
66	1·842.	100·00	100·00	100·0	100·00	94·0	97·87	100·0	100·0

(To be continued.)

Necessity of Light to Vegetation.—M. Boussingault concludes from his own observations, and from the experiments of MM. Pasteur and Ramlin, that "if the solar radiation ceased, not only the plants which have chlorophyl, but also those which are deprived of it, would disappear from the earth's surface." He relies for his data, especially upon his recent observations of "the growth of maize in an atmosphere devoid of carbonic acid," and upon the following experiment, which he performed in 1856: Two seeds of *Helianthus Argophyllus* were planted in calcined siliceous sand, and moistened with distilled water. Nitrate of potash, basic phosphate of lime, and white siliceous hay-ashes were mixed with the sand. In ninety-two days the stalks, the leaves and the flowers of the two plants acquired the same dimensions as those of a *Helianthus* cultivated in the border of a garden for purposes of comparison. This illustrated what the experimenter and M. Dumas have called the "creative power" of plants; the roots acting in sand which contained, in place of the putrefying organic remains which are found in a fertile soil, only pure mineral salts, acting normally, while the plant assimilates the atmos-

[1] Till very recently the sp. gr. of monohydrated sulphuric acid was given as 1·848. See, *e. g.*, "Handbook of Chemistry," by Leopold Gmelin, vol. ii, p. 184 (Cavendish Society's edition).

pheric carbon and organizes the nitrogenous principles of milk, blood and flesh. "Animals do not create, they only transform the principles which are elaborated by the plants." The investigations of eminent physiologists, Mohl, Nägeli, Hofmeister, Sachs and others, show that leaves which are provided with granules of chlorophyl, when exposed to light in contact with carbonic acid and water, give birth to starch, sugar and other analogous substances, such as mannite and lactine, as well as to an emission of oxygen. The presence or the absence of green protoplasm, establishes two orders of cells—those which introduce materials into the organism, and those which introduce nothing, but in which the principles, formed under the double influence of chlorophyl and light, undergo, like the albuminoids, great modifications, either by oxidation or by the intervention of ferments. Similar changes take place in the epidermic cells and in the fluids of the animal kingdom; hence the liver, the lungs, the blood, the milk, contain fat, sugar, inosite, the glycogen discovered by Claude Bernard, of which the properties and the composition are the same as in starch. There are, undoubtedly, plants of a lower order which have no need of chlorophyl or of solar radiation, to build up the materials which are found in the higher organisms of the vegetable kingdom; but there is no living cell which can form a carbonaceous principle, unless it has the faculty of dissociating carbonic acid gas. Plants without chlorophyl, such as mushrooms and yeast cells, are parasites, owing their existence to foreign organisms which have already done part of their work for them. The higher plants, by the co-operation of chlorophyl and light, take all their elements from the mineral kingdom, carbon from the air, oxygen and hydrogen from water. Parasites, on the contrary, take their carbon from substances which have been formed in chlorophyl plants, under the influence of solar radiation. C.

Identity of Motor and Sensitive Nerves.—If a sensitive nerve is pinched, we know that an excitement is sent to the brain; but it is not easy to learn whether any excitement is sent in the opposite direction. M. P. Bert has repeated an experiment, which he first made in 1863, of skinning the end of a rat's tail and grafting it in its back, so as to make a tail in the form of a handle. After the wound has thoroughly healed, he divides the tail, and finds that each extremity is sensitive.—*C. R.*, Jan. 22. C.

WEIGHTS AND MEASURES, DECIMAL.

By S. F. Gates.

The Journal has been the receptacle, from time to time, of reports and communications concerning the various systems of weights and measures for the United States, and within the year past the French system and the metre have been reported upon. With this, an effort will be made to present the decimal (metric) system, using the English foot as the unit of length, instead of the French metre of 39·37 inches, with the hope and desire that we shall find it of more practical use or advantage, than there is, or has been, claimed for the so-called metric system.

To change the decimal scale to any other that may be considered to be better or more convenient in arithmetic, is not the object, but to harmonize the English units of length, weight and capacity, and present the decimal system in such a way as to make it acceptable to everybody.

During my extensive investigations of the metre, the objections to it as the only system for constant and common use by all trades and callings, became positive. The desire to find an arrangement that would answer the purpose, in a decimal ratio, and be agreeable to the English foot as a substitute for the metre, prompted me to look about and see what could be done, and (after I had in mind the basis or formation of what appeared to be a good arrangement) I found reference made to the way I had in view in the last part of the report of your committee (majority report), dated April 19th, 1876; and since that, in the lecture of Sir John Herschel, on the pendulum, the yard and the metre.

"In this lecture the subject is examined from the standpoint of "exact science, and in this regard it is well worthy of attention."

The lecture of Sir John Herschel antedates any effort I have made in this direction. It is pleasing and helps to come to a conclusion, and, I hope, rid us of the irritating contest into which the

[1] See page 7 of the preface to the Metric System, by Charles Davies, LL. D. Published by A. L. Barnes & Co., New York and Chicago. For the lecture in full, see page 319 of the same book.

advocates of the metre have endeavored to force some of us (mechanics and practical men), without a justifiable reason.

The lecturer says: "30. If we are to legislate at all on the subject then, the enactment ought to be to increase our present "standard yard (and of course all its multiples and submultiples) "by one precise thousandth part of their present lengths, and we "should then be in possession of a system of linear measure the "purest and most ideally perfect imaginable. The change, so far "as relates to any practical transaction, commercial, engineering "or architectural, would be absolutely unfelt, as there is no contract for work, even on the largest scale, and no question of "ordinary mercantile profit or loss, in which one *per mille* in "measure or in coin would create the smallest difficulty. Neither "could it be doubted that our example would be very speedily followed both in America and Russia, so soon as the reason of the "thing and the trifling amount of the change came to be understood."

There are other reasons in favor of the arrangement.

SYSTEM.

The foot to be slightly increased in its length, as proposed or arranged by Sir John Herschel, as the scientific unit of length instead of the yard.

Divide the foot into ten parts or *decimal inches*, as well as into twelve parts or inches. This will give us the advantage of two divisions or scales of the foot; both are of service.

Subdivide the foot into tenths, hundredths or thousandths, or carry the decimal divisions to any extent that is desired for the finest measurements or calculations, as now in use to some extent.

Measure of capacity and solid, unit, the cubic foot.

The smaller unit, the cube of $\frac{1}{10}$ of the lineal foot (cubic decimal inch, $\frac{1}{1000}$ part of the cubic foot), and equivalent to one ounce avoirdupois weight.

Measure of surfaces, unit, the square foot.

LIQUID MEASURE.

This part of the system is where the difference is, or has been, and there is the want of a correct proportion or harmony of weight,

length and capacity, in the modern or extremely scientific way of proportioning the whole system to a certain amount of distilled water, under the present admitted or agreed upon conditions, and in conformity with the French measures or system.

The probability is, at the time the system of weights and measures used by the English was discovered or arranged (many centuries ago), chemistry and the science of distilling water were not known, or carried to that extent that they are at the present time, and a certain kind of spring water or sea water was made use of as a basis.

The variation or increased density of water, can be very easily effected, and the required specific gravity to the cubic foot realized without increasing its capacity, and sustain the value of the avoirdupois ounce. Taking this into consideration, it leaves one to believe that the French system (without the metre), as a system, existed and may yet prove to have been in use before the metre was presented to the National Assembly of France, with so much pomp and ceremony, less than one hundred years since.

The decimal unit of capacity or liquid measure in the English system, is wanting; there may be more than one way of making it, but *the gallon is not the proper unit of liquid measure.*

Sir John Herschel, in his lecture referred to, says: "As regards "our measures of *capacity*, the connection would be equally con- "secutive, as a decimal one, between the cubic foot and the half- "pint, which, for the purpose in view, ought to have a distinct name "(such as a '*tumbler*,' or a '*rummer*,' or a '*beaker*'), and which "would contain exactly $\frac{1}{100}$ part of a cubic foot, with whatever "liquid or solid matter it might be filled."

Sir John Herschel proposes to call the half-pint measure, or unit of capacity (containing $\frac{1}{100}$ part of a cubic foot), the "beaker."

To appearance, the unit of capacity, or liquid measure, should conform to the ounce or $\frac{1}{1000}$ part of the cubic foot.

The "beaker," or cup,[1] of ten ounces avoirdupois, would conform to the unit of length (the foot). Both may be used, but the decimal divisions of the ounce, as a unit for chemists and fine measurements, would be best.

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[1] A large size tea-cup, containing nearly ten ounces of pure water.

DRY MEASURE.

The bushel to be made up of a certain number of ounces in capacity or weight.

There appears to be a need of net and gross weights, and to some extent, with the liquid measures, and bear a similar proportion to the wine measure that the gross ton does to the net ton, this to be allowed as a custom to wholesale purchasers—say 10 or 12 per cent., or such a per cent. as the substance may justify, in addition to the net weights or measures for gross, as well as in numbers, or count.

MEASURES OF WEIGHT.

The avoirdupois ounce of 437·5 grains, as the *unit*, instead of the pound.

The ounce to be the unit or basis of every weight—the pound, the net and gross ton, the gallon or the bushel.

FLUID MEASURE.

The liquid avoirdupois ounce decimally divided.

In making up or compounding a prescription or formula, the grain or the ounce, decimally divided, can be used, and conform to the old or proposed system.

The application of the Greek and Latin terms, is in conformity with the French system, and as an illustration, they would naturally be dispensed with in common or everyday use, there is no need of anything more than to enumerate the units of each weight or measure.

Scientific Revision of English Weights and Measures.

Kilo ounces	(1000)	=	1	cubic foot.
Hecto "	(100)	=	$\frac{1}{10}$	of a cubic foot.
Deca "	(10)	=	$\frac{1}{100}$	" "
Ounce	(1)	=	$\frac{1}{1000}$	" "
Deci "	$(\frac{1}{10})$	=	$\frac{1}{10000}$	" "
Centi "	$(\frac{1}{100})$	=	$\frac{1}{100000}$	" "
Milli "	$(\frac{1}{1000})$	=	$\frac{1}{1000000}$	" "
1 ounce		=	437·5	grains.
Deci ounce	$(\frac{1}{10})$	=	43·75	"
Centi "	$(\frac{1}{100})$	=	4·375	"
Milli "	$(\frac{1}{1000})$	=	0·4375	"

Graduated test tubes, glasses, or any instrument for solids, liquids, or elastic fluids, are to be made correctly from the above scale.

The cubic foot of atmospheric air. Its assumed gravity of 1, is the unit of elastic fluids (at present enumerated or represented by grains, in weight), to be decimally divided.

On page 4, of the Report of the Secretary of the Treasury, on the Construction and Distribution of Weights and Measures, dated Washington, D. C., December 31st, 1856, is found the following table of the decimal division of the avoirdupois ounce.

"Those states to which the balances have been delivered have also "been furnished at the same time with a set of avoirdupois ounce "weights, in addition to the above, consisting of the following "pieces:

"One 8 oz.	avoirdupois.				0·02	avoir.	of	silver	wire.
4	"				0·01	"	"	"	
2	"				0·005	"	"	"	
1	"				0·004	"	"	"	
0·5	"				0·003	"	"	"	
0·4	"				0·002	"	"	"	
0·3	"				0·001	"	"	"	
0·2	"				0·0005	"	"	"	
0·1	"				0·0004	"	"	"	
0·05	avoir.	of	silver	wire.	0·0003	"	"	"	
0·04	"	"	"		0 0002	"	"	"	
0·03	"	"	"		0·0001	"	"	"	

The graduated scale beam, or the notches on the edge of the steel-yards, should be divided and made one ounce, or the decimal portion of the ounce, apart. The poise to be the ounce or its equivalent. On one side of the beam, made long divisions of 16 ounces, or pounds; on the other side of the same beam, long marks or divisions of 10 ounces to conform to the decimal divisions.

This conforms to the decimal system of weights and measures, in connection with the foot, and avoirdupois ounce.

To enumerate or arrange the measures of weights, liquid measures, coin, apothecaries' weight, etc., under their various headings, would be to repeat the decimal divisions of the ounce, or the foot, in the form of the French metric tables, by changing the names of the units.

There are, probably, but few people within the United States who are aware that there is in every state of this nation, a decimal

division of weights, or any portion of the decimal system except the French. The English units of weights and measures prove to be equally convenient in use, and should be sustained.

COIN.

Coins, in their weight and diameter, should harmonize with the foregoing weights and measures.

Siemens' Compressed Glass.—In the Siemens' glass-works at Dresden, there is now manufactured a product which has the same properties as La Bastie's tempered glass, the strength being communicated by the pressure of metallic rolls. Plates can be made, by this method, of much larger dimensions than by La Bastie's. They have a beautiful look, and can be ornamented with the most complicated designs, at a less cost than ordinary glass. Siemens claims that glass manufactured by his process has a greater strength than tempered glass, in the ratio of 5 to 3. When broken it shows a fibrous structure, while La Bastie's is crystalline. For equal thickness the resistance of a plate of compressed glass is from seven to ten times as great as that of an ordinary plate. In trial experiments, performed before the Berlin Polytechnic Society, a lead ball weighing 120 grammes was let fall, from different heights, upon plates arranged horizontally and supported only at the four corners. While an ordinary plate was shivered by the weight falling from a height of three decimetres, the plate of compressed glass of like dimensions broke only when the weight was let fall from a height of three metres, and even then only under the influence of many successive blows.—*Deutsche Polyt. Zeit.; Il Politecnico*, April, 1877. C.

Artificial Gold.—Take 100 parts (by weight) of pure copper, 14 parts zinc or tin, 6 parts magnesia, 3·6 parts sal-ammoniac, 1·8 parts quicklime, 9 parts cream of tartar. Melt the copper, and add gradually the magnesia, sal-ammoniac, quicklime and cream of tartar, each by itself, in the form of powder. Stir the whole for half-an-hour, add the zinc or tin in small pieces, and stir again till the whole is melted. Cover the crucible, and keep the mixture in a molten condition for thirty-five minutes. Remove the dross, and pour the metal into moulds. It has a fine grain, is malleable, and does not easily tarnish.—*Phönix; Pap.-Zeitung*, May 24. C.

INFLUENCE OF PRESSURE ON COMBUSTION.

By L. Cailletet.

[Translated from the *Comptes Rendus* of February 22d, 1875, for the Journal of the Franklin Institute, by Chief Engineer Isherwood, U. S. Navy.]

In a communication made to the Academy in 1868, M. H. Sainte-Claire Deville developed a complete plan of the researches commenced in his laboratory at the Normal School, and based on combustion under pressure.

The experiments forming the subject of this note, were conducted according to the principles laid down by M. Deville, and although they were not executed in a laboratory with iron sides and sufficiently large to hold the experimenter and his instruments, yet they were performed with apparatus, which, if not allowing precise calometric measures, had the advantage of being able to show how the phenomena of combustion are modified under pressures which could be carried to 30 or 35 atmospheres.

In order to study the modifications effected by pressure upon the luminous, calorific, and chemical rays from a body in ignition, its combustion had to be maintained during a considerable time; and, consequently, quantities of compressed air, sometimes amounting to hundreds of quarts, had to be provided.

The apparatus employed consisted of the pumps and reservoirs for the compressed gas; the pumps had movable cylinders and fixed pistons, and their leather packings were covered with a column of water or glycerine, which both cooled the compressed gas and prevented its regurgitation. Some canvas tubes, coated with caoutchouc, enabled the gas to be easily directed into either the apparatus for combustion, or into the cylindrical reservoirs, which were of wrought iron, and had been tested to 60 atmospheres.

The laboratory apparatus was a hollow iron cylinder, banded, and having a strength exceeding 300 atmospheres. Four apertures, at about the middle of its height, were fitted with: 1st, the conducting tube for the gas; 2d, the evacuating cock; 3d, the manometer; and, 4th, a plate of thick glass for observation inside. Within this

cylinder, which had an interior diameter of 4 inches, and a capacity of about one gallon, either lamps or the substance to be burned could easily be placed. It is closed by a gum joint, pressed by a blunt metallic screw, whose manipulation is facilitated by a system of counterweights.

When a wax candle is placed in the apparatus just described, the brightness of its flame increases with increased pressure of the air introduced. The base of the flame, which in the atmosphere is transparent and slightly blue, becomes white and very luminous; but very soon the phenomena change, thick clouds of smoke fill the apparatus, and escape through the evacuating cock.[1]

The flame viewed across that smoke was reddish; and, when the experiment ended, the candle-wick was found highly carbonized. The combustion had become incomplete, for considerable quantities of soot were deposited, due, without doubt, to the dissociation of the carbureted gases by the increased temperature of the flame; but the increase was not sufficient to burn a red-hot iron file.

The brilliancy of the flame of phosphorus did not seem to augment under pressure. Potassium burned with a violet-colored and very brilliant flame.

Some lighted wood charcoal in a small furnace, was placed in the laboratory apparatus, and the pressure of the introduced air raised to 25 atmospheres, but the combustion did not seem more vivid than in free air.

An alcohol lamp, whose wick is only a single thread of cotton, giving in free air a scarcely visible flame, increased rapidly in brilliancy as the pressure increased. Under from 18 to 20 atmospheres, it emitted white light as bright and luminous as that of a wax candle; its spectrum was continuous and more expanded than under the ordinary pressure; and the line *D* alone visible, seemed sensibly widened.

The sulphide of carbon gave, also, a more brilliant and luminous flame than in free air; and in burning did not produce sensible quantities of sulphuric acid.

Zinc and hydrochloric acid were placed together in the laboratory apparatus, so as to furnish a jet of hydrogen, but that gas could not be inflamed. An arrangement of the apparatus was tried to prevent

[1] The production of this smoke cannot be attributed to want of oxygen, because the air which escaped by the evacuating cock, normally maintained the combustion of another candle placed under a bell-glass just outside the apparatus.

the hydrogen produced from being driven back into the flask on the admission of the compressed air; but the experiment did not succeed, owing, doubtless, to the slowness with which the acid attacks zinc under pressure.

To sum up: the dissociation of the carbureted gases from the wax candle, and the appearance of the spectrums examined, show the temperature of the combustion to have increased with the pressure, but not in any very great degree.

The brilliancy assumed by the alcohol flame, as well as the coloring of the flames of sulphur and of the sulphide of carbon, show what intensity the luminous rays can acquire by increase of pressure.

That the chemical rays have a greater activity with increased pressure was also established. For that purpose a number of flattened tubes containing phosphorescent substances were joined to the bottom of a blackened box, placed in grooves or guides before the window of the laboratory apparatus. These substances had been selected in such a manner as to give the colors of the spectrum when exposed for a moment to the rays of the sun. It was discovered that several pyrophores, which were not influenced by a given flame, became luminous when the pressure increased; and that those which were influenced by a flame at ordinary pressure, became more splendid when the body producing that flame was burned under higher pressures.

Heat-Ratio.—W. M. Hicks, in an article on "Some effects of dissociation on the physical properties of gases," says: "If, then, the two atoms of a molecule have separated, there seem only two ways of accounting for it. Either their relative motion becomes so large as to overcome the force of attraction, or some external force must act upon them, which can be nothing else than a reaction between them and some other molecules. The latter is the hypothesis I have adopted in the following investigation." Under this hypothesis, by taking the potential energy of combination of a single molecule at its upper limit, he obtains for the theoretical ratio of heat under constant volume to heat under constant pressure, $\frac{c'}{c} = 1{\cdot}423$. This corresponds precisely with the value found by the writer (Proc. Am. Phil. Soc., xiv, 651), $\frac{c'}{c} = 2r^2 \div (r^2 + 4) = 1{\cdot}4232$.—*L., E. and D. Phil. Mag.*, June, 1877. C.

FORCE OF FALLING BODIES.

By J. W. NYSTROM, C.E.

My attention has been called to an article on "Force of Falling Bodies," written by Charles H. Haswell, C. & M. E., published on p. 9, in the July number of the JOURNAL, which article ought not to pass unnoticed, lest it may mislead some readers who, possibly, are not better versed in mechanics.

Mr. Haswell's formula, $W v\ 4{\cdot}426 = M$, expresses momentum of a moving or falling body, and not force, as he asserts. W = weight in pounds, or force of gravity of the falling mass, which is a simple physical element. v = final velocity in feet per second of the falling mass, which is also a simple physical element. M is intended to represent force of a falling body in pounds, which ought to be denoted by F, because it is customary to denote *mass* by M.

The product of the two elements $W v$, is a *function*, viz., momentum, which can never express the *element* force.

Mr. Haswell quotes a formula of mine, for force of a falling body:

$$\frac{W h}{d} = M, \quad \text{which should be written} \quad F = \frac{W h}{d}.$$

This formula is derived from the physical laws involved and expressed by the analogy $F : W = h : d$, which is perfectly correct, and agrees with the experiments of Mr. Haswell; but, unfortunately, he did not make his observations and calculations right; h = height of fall of the body; d = depth of resistance in stopping the body's fall.

These two dimensions, h and d, must both be expressed with the same unit of measure, as feet or inches; but Mr. Haswell has expressed h in feet, and d in inches, which obviously makes his calculation wrong.

Mr. Haswell's given data, $W = 1$ pound, $h = 12$ inches, and $d = 0{\cdot}5$ of an inch, make the force,

$$F = \frac{W h}{d} = \frac{1 \times 12}{0\ 5} = 24 \text{ pounds, instead of 2.}$$

When $h = 24$ inches, and $d = 0{\cdot}5$ of an inch, the force of the falling body will be,

$$F = \frac{1 \times 24}{0{\cdot}5} = 48 \text{ pounds, instead of 4.}$$

This last calculation agrees nearly with Mr. Haswell's experiment, which gave 50 pounds; but he evidently did not measure correctly the depth d. In the first case we have the depth,

$$d = \frac{W h}{F} = \frac{12}{35{\cdot}5} = 0{\cdot}338028 \text{ inch, or } 0{\cdot}028169 \text{ foot.}$$ Second,

$$d = \frac{24}{50} = 0{\cdot}48 \text{ inch, or } 0{\cdot}04 \text{ of a foot.}$$

Mr. Haswell says $d = 0{\cdot}5$ in both cases, which is a physical impossibility.

The fallacy of Mr. Haswell's experiments, with their accompanying formula and expressions, is so palpable that no student of mechanics ought to be misled by them, and it is perfectly correct, as stated by Prof. W. H. Pratt, that Mr. E. E. W. has probably been misled by Haswell.

The following table is given by Mr. Haswell as representing different modes of calculating the force of falling bodies:

Weight and Height of Fall.	Formulæ of W. H. P. $W \times h = M$	G. M. T. $W \times v = M$	P. H. Vander Weyde. $W \times v^2 = M$.	J. W. Nystrom. $\frac{W \times h}{d} = M$	Experiment.
	lbs.	lbs.	lbs.	lbs.	lbs.
1 lb. falling 1 ft.	1	8·02	64.33	2 *	35·5
1 lb. falling 2 ft.	2	11·34	122·66	4 †	50

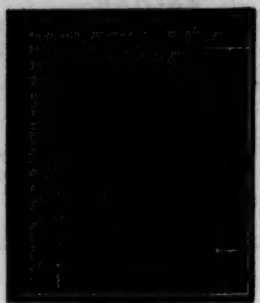
The column headed W. H. P., expresses the function, work in foot-pounds, and *not* the element force in pounds.

The column G. M. T., expresses the function, dynamic momentum, and *not* the element force in pounds.

The column headed P. H. Vander Weyde, has no meaning; but if the formula and numbers be divided by $2\,g$, the quotients will be work, and *not* pounds.

In a lecture on Technical Mechanics, delivered at the Franklin Institute last winter, I made experiments on finding the force of a

* This should be 24 pounds, and † 48 pounds.



falling body by the aid of a pendulum suspended at c, so as to strike a nail at a. The shaded section represents the wooden wall and floor. The weight $W = 2$ pounds, suspended about 10 feet from c, was drawn to b, at which point it was lifted vertically 21 inches, and left to swing against the nail a, which was thereby driven $\frac{3}{4}$ inch into the wood. The problem was to determine the resistance of the wood to the nail, which was solved as follows:

The work in lifting the weight of 2 pounds a height of 21 inches is 42 inch-pounds.

Calling F the resistance to the nail in the wood, the work of driving the nail was $\frac{3}{4} F$ inch-pounds. Those two works must evidently be alike, or $\frac{3}{4} F = 42$, of which resistance F will be

$$F = \frac{4 \times 42}{3} = 56 \text{ pounds, which is the force of the falling body.}$$

If the same weight W was dropped vertically from b, a depth of 21 inches on the nail c, it will drive in the nail the same distance, $\frac{3}{4}$ of an inch, provided the resistance in the wood is the same as at a.

When the weight W and striking velocity V in feet per second are known, and d the distance in inches the nail is driven in, the resistance will be

$$F = \frac{3\ W\ V^2}{16\ d}, \quad \text{and} \quad d = \frac{3\ W\ V^2}{16\ F}.$$

Applying this formula to Mr. Haswell's experiment of a weight $W = 1$ pound falling $h = 2$ feet, in which the final velocity became $V = \sqrt{2\ h\ g} = \sqrt{2 \times 2 \times 32{\cdot}13} = 11{\cdot}34$ feet per second, and penetration $d = 0{\cdot}48$ of an inch, the force of the falling body will be

$$F = \frac{3 \times 1 \times 11{\cdot}34^2}{16 \times 0{\cdot}48} = 50{\cdot}221 \text{ pounds.}$$

Mr. Haswell's experiment gave 50 pounds. The number 16 in the denominator should theoretically be 16·085, which would bring the force down to 49·956 pounds, or 0·044 of a pound less than 50.

THE WATER-PRESSURE BLOWING ENGINE.

By Robt. Briggs, C. E.

One of the earliest applications of steam as a motive power was to set a direct acting engine to pumping water to drive the water-wheel of a grist mill, and from the Journal[1] of June it appears that one of the latest ways of utilizing a water-power, is to use it upon a piston, to translate the reciprocating motion obtained in this way to a rotative motion with a fly-wheel, and then return to reciprocation again to operate another piston of an air-pump.

This combination appears to the writer so peculiarly undesirable, that he now proposes to call attention to what he thinks to be the mechanical purpose of the fly-wheel as a portion of a motive engine. In such an engine the fly-wheel has its place in transforming a pressure on a piston, with rectilinear movement, to the rotation of a shaft, so as to produce a practically uniform angular motion for the transmission of power. And the fly-wheel becomes available as a reservoir of force to enable the varying power derived from the expansion of steam in a cylinder to overcome the constant resistance of the water column on a pump.

Any mass in motion, is as effective as the mass of a fly-wheel in rotative motion, and in deep mines the use of a heavy weight moving at the low speed of a pump, and coming to rest each stroke, is equally efficient in admitting expansion of steam, with a fly-wheel in constant but varying rotation, where the stroke of the pump is measured by the crank.

There is no mechanical or constructive difficulty whatever in obtaining a direct motion from a water-pressure cylinder to an air cylinder—and it is not by any means a new proposition or accomplishment—but it may be allowed that the plan of interposing a fly-wheel to prevent the easy transmission of uniform piston speed is quite as novel as an example as it is undesirable as a precedent. There is no limit to the sequences of mechanical movements—fly-wheels, cranks, gears, beams, cams, etc., etc., but no power is to be derived from them, and every time one or more are resorted to, fitness and necessity for the purpose in view are what constitute the mechanical merit of the

[1] Vol. ciii, page 398.—Rotative Water-Pressure Engine [Blowing Engine].

selection. In the case of one pump driving another, a simple piston rod is obvious enough, assuredly when it is seen that a perfectly regular water-pressure in a motive cylinder is to impart a perfectly uniform pressure to air in the forcing cylinder. The small irregularity from the compression of air at the beginning of the stroke being productive of too small a loss of efficiency to be worth attempting to gain by a fly-wheel. There is an unlimited choice of ways to effect the motion of the valves and control the length of stroke of such a water-pressure engine—any of the old forms of cataract will do. The Davey movement will control the speed for varying heads of water, or for relief of pressure of the air cylinder. Any form of water-wheel governor can be adopted for a speed regulator. If the engines are coupled (as is shown in the JOURNAL referred to), the Worthington movement of one cylinder operating the valves of the other, and the contrary, is available. If the highest water-power possible were desired, it can be attained by the use of a beam between two cylinders, with an adjustable beam-centre so as to change the stroke of the water cylinder. The good modifications of the water-pressure blowing engine are innumerable; but the particular form which puts in a heavy fly-wheel to disturb the natural regularity of motion, uses air chambers to relieve the artificial disturbances, and, finally, at great cost for original construction, and with large addition to the wearing parts, subjected to inordinate wear, takes the form shown in the JOURNAL, is hardly a good type to copy.

Textile Adulterations.—Thin sections, perpendicular to the axis of the fibres, have furnished M. Vetillart various marks for distinguishing linen from hemp, as well as from jute and other foreign fibres. To those purely microscopic indications he has added others of a chemical nature. A mixture of sulphuric acid and glycerine, acting on fibres which have been previously impregnated with iodine, colors some blue and others yellow, thus establishing two easily distinguishable divisions. A combination of the two methods shows different characteristics in different families, and even gives the means of often distinguishing the different genera of the same family. Thus the anatomical structure of vegetables furnishes data for classification, parallel to those of animal morphology.—*Soc. d'Enc. pour l'Ind. nat.; Les Mondes*, May 24. C.

THE ASHTABULA BRIDGE DISASTER.

An article in the JOURNAL for February, 1877,[1] upon "Governmental Interference for Prevention of Accidents," suggested by the burning of the Brooklyn Theatre and the fall of the Ashtabula Bridge, contains a strong argument in favor of the inspection of railroad bridges by officers to be appointed under an Act of Congress.

The opinions expressed at that time could have no more forcible confirmation than that furnished by the "Report of the joint committee, concerning the Ashtabula Bridge accident, under joint resolution of the General Assembly of Ohio," from which the following extracts are taken.

It will be remembered that this bridge, located near Ashtabula, Ohio, on the line of the Lake Shore Railroad, gave way on the evening of Friday, Dec. 29th, 1876, causing immense loss of life and property. The Ohio Legislature, being then in session, authorized the appointment of a committee to investigate the causes of the accident. On January 16th, the committee was on the spot for the purpose of making personal examinations and taking testimony, and two days later, three engineers, employed to take measurements and make calculations, were also there and at work. The accident was so unusual a one, that it attracted the earnest attention of all the engineers of the country, and several of them visited the wreck and made personal examination without reference to official investigation, and the committee availed themselves of the services of some of them. The witnesses examined included the President of the road, who was also the projector of the bridge, the chief engineer of the road, the master mechanic who constructed, and the carpenter who erected, and the engineer who made the original drawings of the bridge, and a considerable number of experts.

The published report is accompanied by all the testimony and statements made to the committee, by plates showing the general plan and details of the structure, and a draft of a bill to be presented to the Legislature, "to secure greater safety for public travel over bridges," making an 8vo. volume of 158 pages.

"The bridge consisted of two trusses of the Howe-Truss type, executed in iron, and carrying two tracks on the upper chords or deck, and was of the following general dimensions:

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[1] Vol. ciii, p. 75.

"Length of span between abutments,	150	feet.	
" " " centres of half blocks,	154	"	
" of each panel,	11	"	
No. of panels,	14		
Height from centre to centre of chords,	19	"	8 in.
" " out to out,	20	"	0⅜ "
Width in clear between trusses,	14	"	0 "
" from out to out of trusses,	19	"	6 "

"The floor-beams were spaced 8 feet 8 inches, centre to centre, and consisted of rolled iron I beams, 4 inches by 6 inches, and were 25 feet 3 inches long, projecting 2 feet 10½ inches over each truss.

"The bridge carried two tracks, 4 feet 8½ inch gauge, the outer rails of which were directly over the centre of each truss.

"The track stringers under the outer rails, consisted of two pieces, 6 inches by 14 inches, and, under the inner rails, three pieces, 6 inches by 14 inches, besides which there were bearing stringers on the outer ends of the floor-beams, each one piece 6 inches by 14 inches, all of white pine.

"The deck was 3 inches thick and 26 feet wide, and was laid *close*, covering the entire surface.

"Along each side of the floor, was a pine-guard rail, 10 inches by 10 inches, bolted through the deck and bearing-girder to the floor-beams.

"Each truss rested on expansion-rollers at the east end."

Of all the information as to the causes of the disaster, that of the three engineers employed is as likely to be based on disinterested engineering skill as any, and, as it agrees in the main points with all the other experts' testimony, is entitled to great weight. They give the following as the result of their examinations and calculations:

"First. That the factors of safety are extremely irregular, and vary through a wide range.

"Second. That all the tension members have very large factors of safety, and were abundantly able to sustain all the strains that could possibly come upon them in this bridge.

"Third. That all compression members, except the counter braces, are deficient in capacity, having very small factors of safety.

"Fourth, shows the factors of safety based on the ultimate *crushing* strength of the metal, without taking into account the tendency to flexure in a long column. Upon this hypothesis the factors of safety are shown to be reasonably large, and correspond more nearly with the factors for the tension members; and it may be that the original calculations were made on this fallacious assumption.

"Fifth. Considered with reference to the location of the break, it appears that the weakest point, as to the braces, was in the third

panel, and that the weakest point in the top chord was at the centre, though the top chord, at the point of failure, does not show a state of security much greater than that of the braces.

"The probability is that the braces failed first, and thereby involved the failure of the top chord also. But inasmuch as both members were weak, and both were involved in the break, it is of little importance which member took precedence in the failure. The factors of safety throughout the compression members were so low that failure must have followed sooner or later.

"If the several groups of beams composing the braces and top chord had each been combined into a single member, by riveting on to their flanges a system of diagonal plates—say three and a half by half inch—running alternately from right to left and from left to right across the entire group, the bridge would have been abundantly safe. This arrangement would have made each group strongest in the lateral direction and weakest in the direction of the webs of the beams; but in this direction the beams offer about five times the resistance that they do laterally. The top chord members could then only deflect in single panel lengths, and on that account their strength would have been still further increased—twofold. The result would have been that the factors of safety given in the tables would have been increased *five times* for the braces and *ten times* for the chord. They would have been so excessively strong that much of the material might have been omitted.

"There were several other defects in this bridge, some of which have been already incidentally alluded to, but which we do not regard as causes of this disaster.

"As to the adaptability of the Howe truss type of bridge for execution in iron, we would say, speaking generally, that any ordinary type of bridge *can* be made abundantly secure, in either iron or wood, if the resisting material is properly proportioned to meet the several strains, and the workmanship is properly executed; and that a failure to provide sufficient materials in any one or more members would be equally fatal in any case. The relative merits of the several types of trusses depend chiefly on questions of economy of construction. The Howe truss type would not be as economical in iron as some others; but if built of proper strength in all its members, would be a good and serviceable bridge.

"In conclusion, we would say that we find nothing in this case to justify the popular apprehension that there may be some inherent defect in iron as a material for bridges. The failure was not due to any defective quality in the iron. It was not owing to the sudden effect of intense cold, for failure occurred by bending, and not by breaking. It was not the result of a weakness gradually developed after the erection of the bridge. It was due simply to the fact that it was not constructed in accordance with certain well-established

engineering principles. We find no evidence of any weakness which could not have been discovered in the plan and avoided in the construction."

As a summary of the whole investigation, the committee, from personal observations and calculations, and a patient and careful consideration of all the evidence within reach, arrive at and report the following conclusions:

"1. There were from eighty to one hundred lives lost by the failure of the bridge.

"2. The bridge went down under an ordinary load by reason of defects in its original construction.

"3. *The defects in the original construction of the bridge could have been discovered at any time after its erection by careful and analytical inspection, such as the importance of the structure demanded, and thus the sacrifice of life and property prevented.*" K.

ON THE MANUFACTURE AND USE OF TERRA-COTTA DRAIN AND SEWER PIPES.

By Prof. L. M. Haupt.

[Contribution from the Department of Civil Engineering, Towne Scientific School, University of Pennsylvania.]

Terra-Cotta is a variety of earthenware, and for pipes in this locality, it is composed of a stiff clay from Woodbridge, N. J., mixed with a substance called "chamotte," which is made of ground up fragments of firebrick and broken pipes which have been burnt. It is prepared in three sizes, known as Nos. 1, 2 and 3, and is used to prevent the pipes from warping or cracking in drying and burning.

The clay is first placed in sheds where it is allowed to season. It is then worked over at least twice in a pug mill, from which, as it issues, it is conveyed by means of buckets on an endless band to the top of a vertical hydraulic press, capable of containing a charge of ten tons (or less). A conical head having an annular aperture equal to the exterior diameter of the pipe to be made, is attached to the bottom of the press, which is elevated on columns; and to prevent the clay from being forced out in a solid mass, a conical plunger is suspended within and just over the aperture, leaving a space equal to

the thickness of the pipe to be formed. The clay is forced out in a continuous vertical stream, and received upon a skip or small platform, placed upon the head of a piston, which descends with an equal velocity. Each length of pipe is cut off by drawing a brass wire across the mouth of the press, and then carried on a low truck to the moulding room.

If bell pipe is to be made, the moulder, whose hands are protected by leather or horn shields, moistens the rim of the clay cylinder, which has been placed on the potter's wheel, turns it out and down, and by gentle pressure, whilst revolving rapidly, forms the desired recess. It is then conveyed to the drying room over the kilns, where it remains until quite hard.

The next operation is that of applying the glaze, which may be done either in the kiln, by sprinkling salt into it when at a white heat, or by dipping each pipe into a solution of Albany earth, a clay possessing the peculiar property of fusing when heated. The first is known as the "salt," the second as the "slip" glaze, and an animated controversy has arisen in regard to the relative merits of the two glazes.

The first is evidently much cheaper, as it is only necessary to sprinkle a bushel or more of salt into the mouth of the kiln, and the operation is complete; but not so the glazing, for the pipes are placed in "nests," that is the smaller ones are inserted in those of larger bore, and supported by the bell at the top, like a telescope, completely closing the interior surfaces of all the pipes except the smallest one, and thus preventing the vapors from reaching them. Even should the glaze cover every portion of the surface, it is not permanent, for from the nature of the ingredients it will contain silicate of soda (Na_2SiO_3), which is "*soluble glass.*" In fact, several specimens of salt glaze have been tested by placing them in an acid solution, which dissolved every particle of the glaze; while the slip glaze, subjected to precisely the same tests, remained untouched.

Slip glazing is performed by placing the pipes upon a grating, which is lowered into a tank containing the Albany earth in solution. In this way, every particle of the pipe, inside and out, is covered, and considerable "slip" is absorbed by the pores of the dry clay, forming not merely an adherent scale, but a homogeneous mass, which is burnt in and vitrifies at the burning of the pipe.

Pieces of slip-glazed pipes, exhumed after many years of use in drains, are found to be unaffected by the sewer gases and in as good condition as when first laid.

The question of terra-cotta *versus* brick for sewer material, is one in which every member of the community is, whether knowingly or not, directly interested. The advantages of the former substance are so self-evident as scarcely to need mentioning; yet, so difficult is it to remove a prejudice or overcome a conservatism rooted in custom, that a series of practical experiments were recently arranged, and a large committee of our City Fathers invited to be present, that they might decide the question of the relative advantages of the two materials.

Two parallel sewers were built, of equal dimensions of aperture and length, on the same grade—one of brick, the other of terra-cotta; and to demonstrate the facility with which solids would pass through, a marble was laid at the upper end of each. It immediately rolled through the terra-cotta pipe, but lodged in the brick sewer at 9″ from the starting point. Buckets of water filled with chips were then thrown in, with a similar result; all the water and chips being carried through the terra-cotta sewer, whilst none of the water nor chips came out from the end of the brick one. To show how freely the noxious gases escaped from our ordinary sewers, some oil waste was ignited and thrown into each, and the ends closed. The result was astonishing, for from every pore of the bricks dense black smoke issued in volumes, whilst hardly the slightest trace was discernible in the other case.

To present a perfectly fair and just comparison, the brick sewer was supported in a trough filled with sand, to sustain the lower segment which is usually laid *dry* upon a cylindrical bed. The upper segment contains some mortar, the whole being held together by the pressure of the surrounding earth. Now, if from any cause the earth be removed from the exterior, the bricks fall and the passage is barricaded. To show the weakness of such construction, the outer plank, forming the trough supporting the brick sewer, was knocked away, when the whole structure suddenly collapsed.

Such accidents frequently happen from leaks, and the myriads of rats that infest these underground passages, undermining the bed of the work.

Another consideration, in favor of terra-cotta, is that of the closeness and neatness of the joints and intersections with other sewers

and drains, and the ease with which they may be given the proper curves, so as not to interrupt the flow of sewage in the main channel, and thus cause deposits.

So *fragrant* are the evils of the brick sewer system, with its open inlets and silt basins where fœcal matter is allowed to putrefy during the summer months, that it is only necessary to pass near one and let it speak for itself. Yet the most subtle and poisonous gases are not those which emit a sensible vapor, but are unperceived until, like the disaster at Wheatland, it is too late. Every day we unconsciously inhale more or less of these deadly vapors unnecessarily, through defective sanitary measures, and from motives of economy, dearly bought. The sewage permeates the bricks and crevices, and saturates the soil, whilst any increase of pressure in the gases of the sewers forces them back through the traps, if there happen to be any, into the streets, unfiltered and foul. This fact is verified by carefully collected statistics, showing in England a reduction in the death rate in every case where effective sanitary works were resorted to. Mr. B. Latham cites twelve cases of cities and towns, with populations ranging from 7818 to 68,056, and death rates varying from $19\frac{1}{10}$ to $33\frac{2}{10}$ per 1000, in which, after the completion of the sanitary works, the rate was reduced to from $18\frac{6}{10}$ to $26\frac{2}{10}$ per thousand, with a diminution in some of typhoid fever cases from 10 to 75 per cent., and from 11 to 49 per cent. in cases of phthisis.

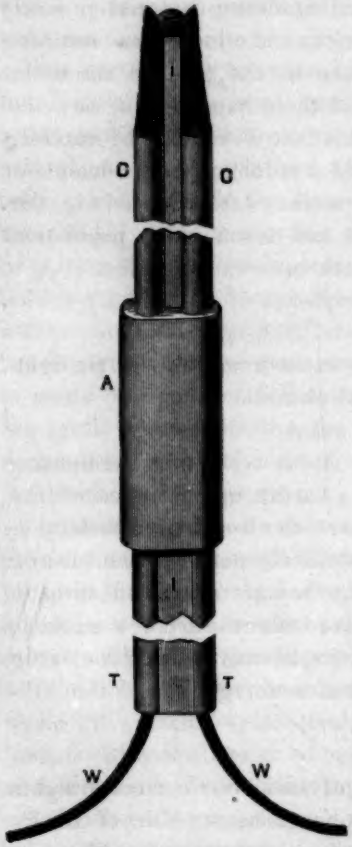
It is estimated that "there are 28 cases of sickness for every unnecessary death" from these causes. As it seldom happens that a sick man is a benefit to, but rather a burden upon, the community, it is of some pecuniary value to increase the health of a locality by all reasonable means. There are many other important considerations bearing directly upon this subject, but they are beyond the scope of this communication. Its aims will have been reached if it excites a more general interest in the matter of improving the health of cities by introducing a more efficient system of sewerage.

Siberian Mammoth.—The recently discovered carcass was in the gold-bearing sands of the river Kundola, at a depth of five metres. The flesh was very soft and of a light red color, when first dug out, but it soon hardened, becoming like a white clay. It seems to be much impregnated with lime.—*Nature.* C.

THE JABLOCHKOFF ELECTRIC CANDLE.

DESCRIPTION.[1]

In the accompanying figure we illustrate the electric candle as used by M. Jablochkoff for his experiments in Paris. The illustration is full size, but reduced in length by breaking, and is reproduced from the French journal, *La Nature*, with a slight alteration of the lettering only. The "candle," as we explained in our issue for May 18th, is now employed only in cases where a powerful light is required, the simpler porcelain burners being used for lighting purposes where a number of burners of medium intensity are necessary. The "candle" shown is, we believe, not the latest of M. Jablochkoff's designs, but it illustrates definitely the principle upon which his improvements in the electric light are based. *A* is a holder of asbestos, supporting the two carbon rods, *C*, turned to a cylindrical shape, as shown, out of gas retort scale. These rods are held in tubes *T*, of brass, or copper, preferably the latter, and are separated by the insulating material, *I*, consisting of a compound which has received the name of kaolin. When the current passes, being brought to the candle by the wires *W*, the electric arc is produced, and the heat vaporizing the insulating material as the carbons are consumed, the relative distances are always preserved. If a continuous current is used, the double consumption of the positive rod is provided for by making it double



[1] *English Mechanic and World of Science*, June 15th, 1877.

the sectional area of the negative, but the candle works better with alternating currents, in which case the carbons are of the same size. It is easy to reverse the apparatus so that the arc is produced at the lower ends of the rods. The candle may then be employed for an overhead light. One of the principal advantages of this lamp is, that it may be set in operation at a distance. M. Jablochkoff accomplishes this by placing a piece of carbon between the points. When the current passes, this becomes hot, reddens, and finally consumes. Continuity is then broken, and the arc appears. A bit of lead or of fine metallic wire, which melts easily, answers the same purpose. The gradual fusion of the insulating material presents another advantage—namely, that it becomes conductive on attaining the liquid state, and admits of an elongation of the arc, which increases the light. This conductibility, moreover, admits of the re-ignition of the candle after it has been extinguished by the breaking of the circuit, provided the interval is not longer than a couple of seconds. By this means, it has been suggested, the candle might be employed for transmitting signals by flashes, using the Morse telegraphic alphabet and the Mance heliograph.

TRIAL IN LONDON.[1]

On Friday, the 15th inst., a trial was made of the electric lighting apparatus invented by M. Jablochkoff, and known as the "electric candle," at the West India Docks.

"The proceedings commenced soon after 9 P.M., with the lighting of four electric lamps in the court-yard at the entrance of the docks. The lamps were arranged at distances 45 ft. from each other in one direction, and 20 ft. in the other. The light of the electric candle in each lamp was subdued by being transmitted through ground glass globes. The light was steady after the first few minutes, and that of one lamp was sufficient to enable small print to be easily read 20 yards away. The light was produced from one of the Alliance Company's (Paris) electro-magnetic machines, having 32 magnets of six plates each, and being driven by a small portable steam-engine. After burning for a quarter of an hour, the electric lights were extinguished, and four gas-lamps, each having four of Bray's No. 6 burners and four powerful reflectors, were lighted. The con-

[1] *Journal of the Society of Arts*, June 29th, 1877.